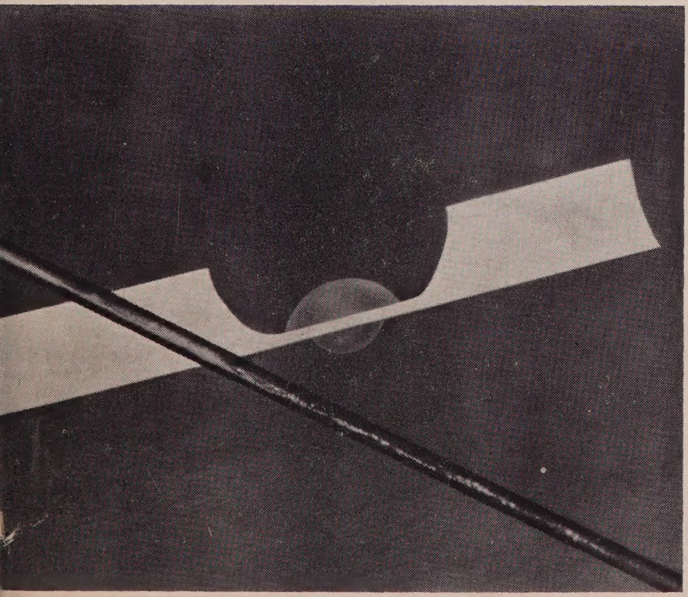
APRIL · 1954

Proceedings of the I·R·E

A Journal of Communications and Electronic Engineering

Volume 42 Number 4

HIGH-FREQUENCY TRANSISTOR



Radio Corporation of America

cross section of a high-frequency alloy junction transistor is ıpared above with a human hair. The center section is made emely thin to enhance amplification of high-frequency signals. operation, connecting wires are embedded in the two grey ds in the center.

IN THIS ISSUE

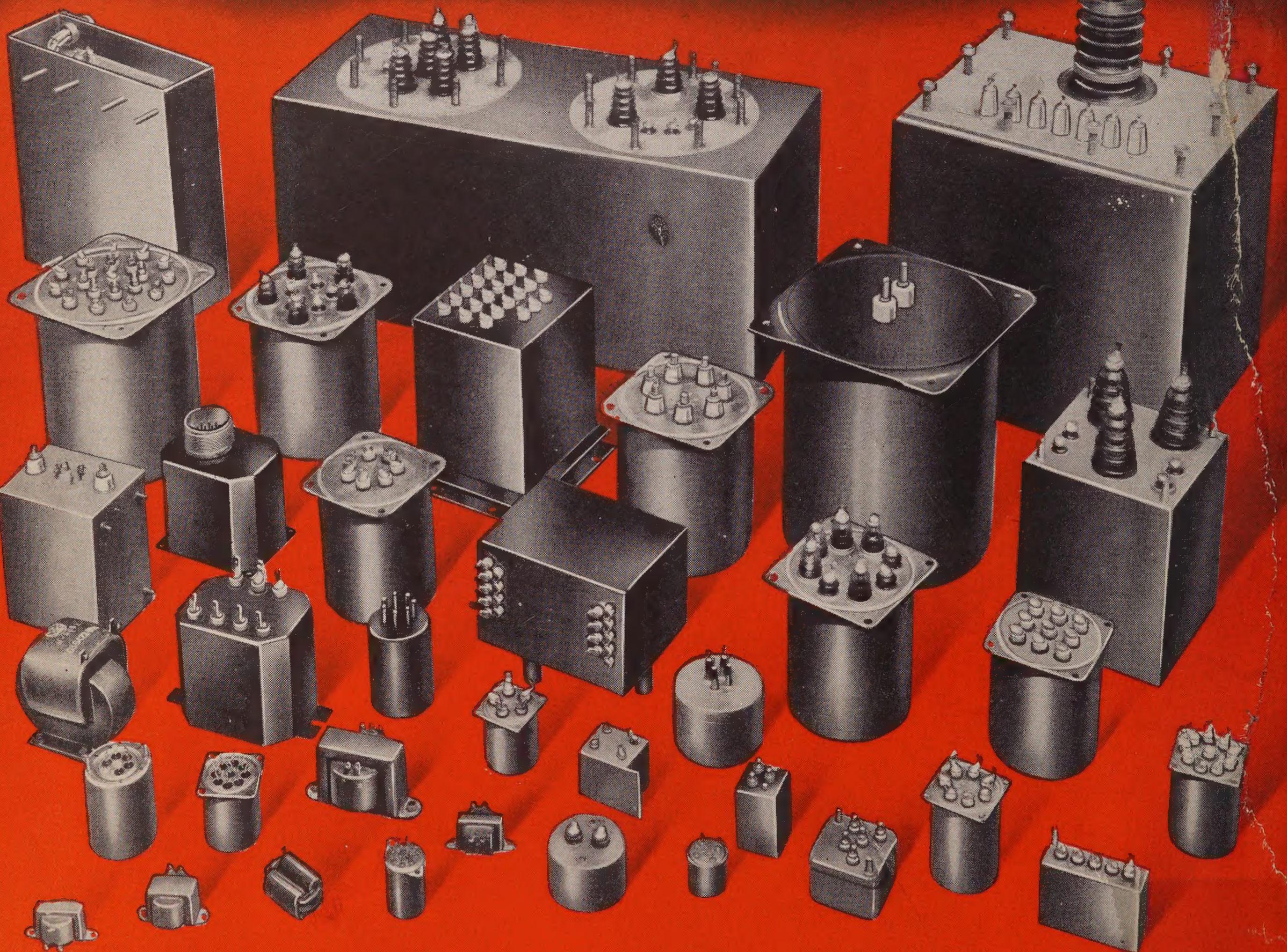
IRE—Past and Future
DC Transistor Amplifier
90° Phase-Difference Networks
ULF Three-Phase Oscillator
Solving Large Systems in Easy Stages
Radiation Resistance of Ring Quasi-Array
Voltage-Controlled Logarithmic Attenuator
Geometric Aspects of Least Squares Smoothing
Radio Progress During 1953
Abstracts and References

TABLE OF CONTENTS INDICATED BY BLACK-AND-WHITE MARGIN, FOLLOWS PAGE 64A

U. OF I.
LIBRARY

The Institute of Radio Engineers

U.T.C. for MILITARY COMPONENTS



Precision
Production to
Military
Requirements

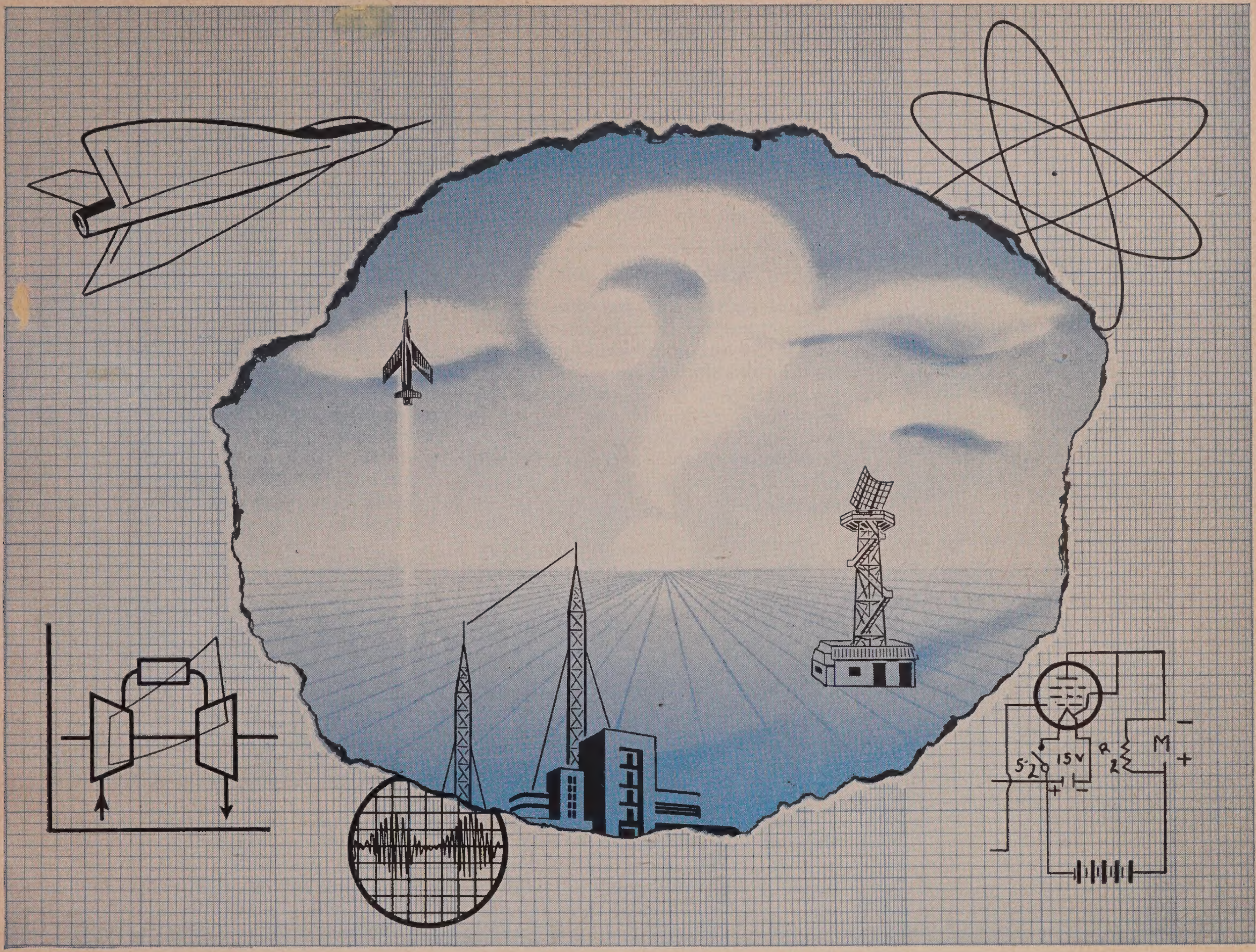
The manufacture of transformers and associated devices for military requirements has been a specialty of U.T.C. for the past fifteen years. Thousands of military designs are in present production . . . a few examples are illustrated above.

In this photograph you will find transformers, reactors, filters, high Q coils, and magnetic amplifiers. Types illustrated include units to MIL-T-27, JAN-T-27, and ANE-19.

If you have a tough problem in an Hermetic or Fosterized unit, U.T.C. is your logical production source.

United Transformer Co.
150 VARICK STREET NEW YORK 13, N. Y.
EXPORT DIVISION: 13 EAST 40th STREET, NEW YORK 16, N.Y., CABLES: "ARLAB"

NEW HORIZONS IN ENGINEERING



When products are undefined **but performance can be specified**

. . . the Special Products Division of I-T-E may be helpful.

We don't claim to solve all development problems to meet performance specifications, but we may have the answer you're looking for. Our record in helping with unusual and advanced developments is impressive. Our current projects range from design, development and fabrication of Radar Antenna Systems to equipment to operate on advanced Thermodynamic theories. Whether your problem is new development – or fabrication with new and hard-to-work alloys – you'll want to know how this unique organization can help you.

Send for Publication SP-100 PI4 today.

RADAR ANTENNA SYSTEMS
design, development and fabrication

JET ENGINES
manufacture of major hot-end components

THERMODYNAMICS
design, development and fabrication of equipment to operate on advanced theories

GUIDED MISSILES
advanced fabricating techniques

TITANIUM
proven welding, forging, forming, spinning techniques with this hard-to-work metal

SPINNING
combining spinning and drawing to an almost limitless variety of designs in a wide range of metals

TECHNOLOGY
ABILITY
FACILITIES

SP 10.2

SPECIAL PRODUCTS DIVISION

I-T-E CIRCUIT BREAKER COMPANY

601 E. Erie Avenue • Philadelphia 34, Pa.

Progress through Problem Solutions

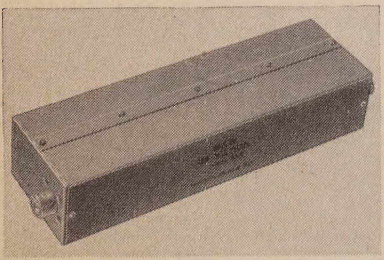
49121

NEWS and NEW PRODUCTS

April 1954

Low Pass Filters for TVI

Two new low-pass filters designed to help the radio amateur overcome TVI more effectively have just been announced by **Barker & Williamson, Inc.,** 237 Fairfield Ave., Upper Darby, Pa.



The wave guide principle employed in the design of these filters makes possible a type of mechanical construction which allows more sections to be built in less space. The result is a high order of attenuation, 85 db through the TV band with more than 100 db on TV Channel #2. With an attenuation of 85 db equivalent to a voltage ratio of 17,780 to 1, this means that a transmitter equipped with one of these filters will have undesirable harmonics causing TVI reduced by a minimum factor equal to 17,780/1.

Both filters can handle more than 1 kw of modulated rf power continuously, as indicated by laboratory power test runs under conditions of feed line mismatch within the normal expectancy limit. Insertion loss is less than 0.25 db through the entire pass band to 30 mc.

Each filter consists essentially of four "K" sections, plus two "M" derived and sections, in a copper sheet, screw-assembly case. Teflon insulation is used throughout.

These new filters, available in 52 ohm and 75 ohm impedance models, can be applied in AM, FM, CS, FS, RITTY, and SSB, services. Complete details are given in a data bulletin available upon request.

Transformer Catalog

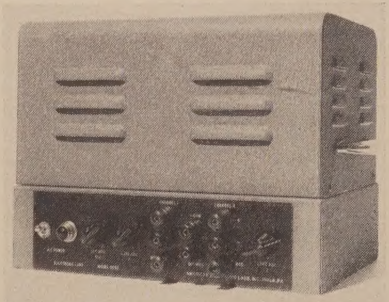
An 18 page catalog offered by **Standard Electrical Products Co.,** 2240 E. Third St., Dayton, Ohio, illustrates and describes their full line of Adjust-A-Volt Variable Transformers. Design and construction details, dimensions and performance characteristics of the various models of auto, isolated and metered variable transformers for built-in and bench applications are included.

Adjust A-Volt Variable Transformers in standard bench or panel mountings as well as ganged assemblies are described. Terminal and tap arrangements as well as circuits diagrams are included along with a convenient index of specifications and applications for all single phase and three phase transformers covered by the catalog. The many uses for toroidal winding are discussed in a special section. The catalog and other information will be sent upon request.

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

Electronic Load

An electronic load for both static and dynamic measurements on dc power supplies is now available from **American Electronic Laboratories, Inc.,** 641 Arch St., Philadelphia 6, Pa. It provides a direct method of measuring the internal impedance of a regulated power supply as a function of frequency and determining the range of load over which the regulation is effective.



The instrument contains two individual channels with independent static load adjustments. The channels may be interconnected, however, for a total average power range of 150 watts. A wide range of currents may be drawn at various applied voltages so long as the maximum ratings of tubes are not exceeded. Provision is made for both external and internal modulation of load tubes for dynamic regulation checks. A 1 ohm resistor is also provided to allow a voltage output proportional to load current to be obtained for observing voltage-current waveforms on oscilloscope.

The instrument is housed in a 12×8×9 inch high cabinet with carrying handles and obtains necessary internal voltages from the 115 volt, 60 cps line.

Components Catalog

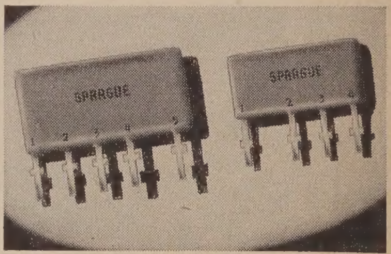
Catalog RC-9 contains information on the complete line of fixed and variable composition resistors, line and slide switches, fixed composition capacitors, powdered iron cores, molded coil forms, and Ceramag ferromagnetic cores manufactured by the **Electronic Components Div., Stackpole Carbon Co.,** St. Marys, Pa.

Complete electrical and mechanical specifications, dimensions, and application data are given in the new 56-page catalog. The section on iron cores contains over a dozen pages on the selection and use of Stackpole standard, threaded, sleeve, side molded and cup cores. In addition, the catalog includes the most recent data on Stackpole Ceramag ferromagnetic cores as well as descriptions of several new applications for this material.

Copies of the new Catalog RC-9 are available on letterhead request to Stackpole.

Printed Circuits with "Dagger" Terminals

Designed for use in the assembly of printed circuits on etched, sprayed, plated, and stamped wiring boards, are a new series of Bulplate resistor-capacitor networks made by the **Sprague Electric Co.,** 235 Marshall St., North Adams, Mass., and its subsidiary, the Herlec Corp. of Grafton, Wis. The dagger terminals are convenient where wiring is used on both sides of a board. The shoulders on the tabs separate the assembly from the wiring. Bulplates with this type of terminal can be positioned to permit automatic assembly on the circuit boards with the plate supporting itself during automatic dip-soldering operations.



Various types of standard integrators, diodes, filters, decoupling, output, and coupling networks are being supplied with the new terminals to meet customer circuit specifications. In some cases, the shoulders on the tabs are being omitted to permit the network to seat itself against the wiring boards when used with boards on which the wiring appears on one side only.

Meter Calibrator

The **Kalbfell Laboratories, Inc.,** P.O. Box 1578, 1098 Morena Blvd., San Diego 10, Calif. Meter Calibrator line has been expanded and models are now available that afford precise voltage and current reference. Units are available covering the range from 0 to 1,000 volts and from 0.05 microamperes to 100. These units employ the "KAY-LAB absolute dc power supply system."

All currents and voltages are referenced against an internal standard cell that maintains the output constant regardless of line or load variations. These models feature 0.01 per cent stability, calibration, and regulation.

(Continued on page 31A)

4 mmf/ft

AIR-SPACED ARTICULATED

CO-AX

CABLES

offer a unique combination of

✓ FRACTIONAL CAPACITANCE

✓ HIGH IMPEDANCE

✓ MINIMUM ATTENUATION

ALONG WITH

✓ EXCEPTIONAL FLEXIBILITY

✓ LIGHT WEIGHT

38 STOCK TYPES

FOR ANY OF YOUR STANDARD OR SPECIAL APPLICATIONS

A few of the very low capacitance types are:

Type No.	*Capacitance* $\mu\mu$ *F/ft.*	*Impedance ohms*	*O.D.*
C.44	4.1	252	1.03"
C.4	4.6	229	1.03"
C.33	4.8	220	0.64"
C.3	5.4	197	0.64"
C.22	5.5	184	0.44"
C.2	6.3	171	0.44"
C.11	6.3	173	0.36"
C.1	7.3	150	0.36"

WE ARE SPECIALLY ORGANIZED TO HANDLE DIRECT ORDERS OR ENQUIRIES FROM OVERSEAS

SPOT DELIVERIES FOR U.S.

BILLED IN DOLLARS—SETTLEMENT BY YOUR CHECK

CABLE OR AIRMAIL TODAY

TRANSRADIO LTD.

CONTRACTORS TO H.M. GOVERNMENT

138A CROMWELL RD., LONDON, S.W.7
ENGLAND

CABLES: TRANSRAD LONDON

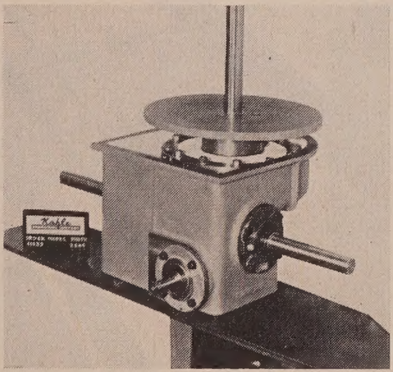
News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

(Continued from page 24A)

Indexing Mechanisms

Indexing mechanisms capable of indexing up to 2400 per hour are now available separately for installation on the buyers' own tables or incorporated in their machines. **Kahle Engineering Co.,** 1037 Seventh St., North Bergen, N. J. developed these units as part of the custom-built automatic machinery used in the electronics and glass industries in applications such as annealing, fire polishing, sealing, and so forth.



Model 2248 Index Mechanism is a typical example offered and may be had with or without turrets. This model has 12 position index. It can also be produced for 8, 12, 16, 24, 30, 32 and 48 positions.

Model 2144A is a typical Kahle Indexing Machine Chassis with 8 position index mechanism and turret. Features include: Standard Kahle Index Mechanism, Dual-Motor Drive (one motor operates the Index Mechanism and associated cams; a second motor operates the Head Drive Mechanism), Timer-Index Control (length of dwell may be controlled from 1 second upward to any desired length in seconds, minutes or hours), Automatic Head Stop (rotating heads are automatically stopped in predetermined orientation, usually in two positions, namely, loading and unloading), Universal Head Receptacle (heads may be inserted, omitted, replaced by simply tightening or loosening the set-screw). Anti-friction bearings are used throughout.

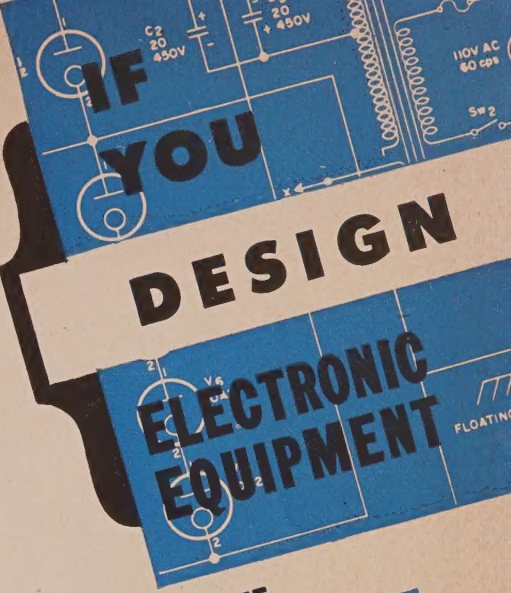
Capacitor Catalog

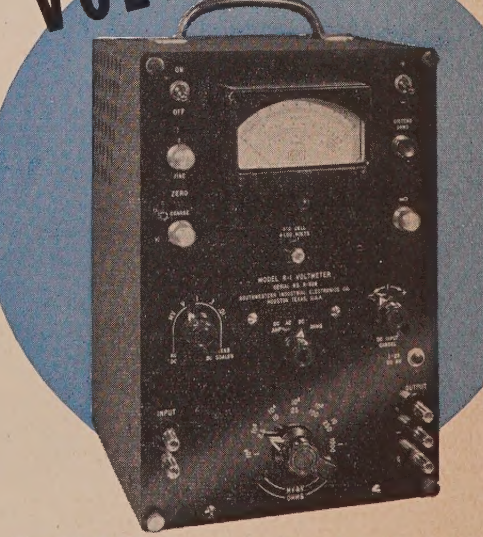
Cornell-Dubilier Electric Corp., South Plainfield, N. J., has just issued a new 36-page catalog. All the data for any of the 134 types of C-D replacement capacitors is presented.

Many of the capacitors listed will also be of interest to industrial and experimental users. Information includes specifications, diagrams, photographs, and prices.

One of the features of this new 1954 catalog #200 is the inclusion of two "Contents" indexes—one index according to Capacitor Classifications, the other according to Type Number or Brand Name.

(Continued on page 36A)


IF YOU DESIGN ELECTRONIC EQUIPMENT



YOU NEED THE SIE

MODEL R-1 AC-DC VOLTMETER

The SIE R-1 Voltmeter is the only instrument of its kind especially designed as a precise laboratory meter for measuring AC and DC voltages from .0001 to 1,000 volts. It incorporates a stable direct-coupled oscilloscope pre-amplifier, a wide-range ohmmeter, a standard cell for calibrating and the SIE "Distended DC Scales" for measuring small changes in large voltages with an accuracy of .01 percent. In circuit analysis, design and development, this voltmeter replaces instruments whose total cost is many times as much. Covering the frequency range from DC to 100 kc, it finds application in audio, ultrasonics, geophysics, servo-mechanisms, computers, vibration analysis and general instrumentation. Price f.o.b. Houston: Complete with line cord, test leads and instruction manual . . . $620.00. Specify bench or rack-mounted model.

Write today for descriptive literature.

SOUTHWESTERN INDUSTRIAL ELECTRONICS COMPANY

2831 POST OAK ROAD

The old Roman god Janus lives today in servo mechanisms, instruments, and controls which take past information and use it to guide the future—much as Janus faced backward and forward in time, to symbolize past and future.

time in your hands

Controlled, predictable flight depends upon data concerning the immediate past of a flight, as well as navigational information for the course ahead. Time is literally in your hands with Kollsman products.

Today our activities encompass four fields:

AIRCRAFT INSTRUMENTS AND CONTROLS
OPTICAL PARTS AND DEVICES
MINIATURE AC MOTORS
RADIO COMMUNICATIONS AND NAVIGATION EQUIPMENT

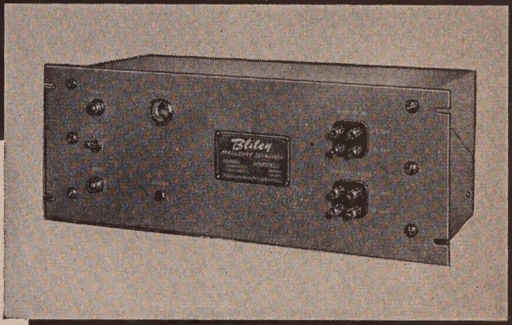
Our manufacturing and research facilities . . . our skills and talents, are available to those seeking solutions to instrumentation and control problems.

kollsman INSTRUMENT CORP.

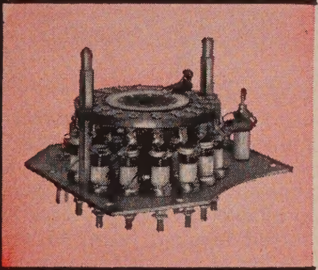
ELMHURST, NEW YORK • GLENDALE, CALIFORNIA • SUBSIDIARY OF *Standard* COIL PRODUCTS CO. INC.

BLILEY
BH6A
CRYSTAL

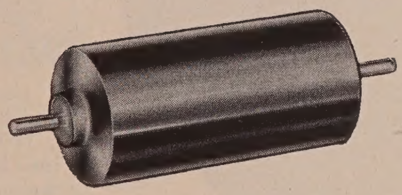
★ **BLILEY TYPE BH6A**



★ **BLILEY TYPE BCS-1A**

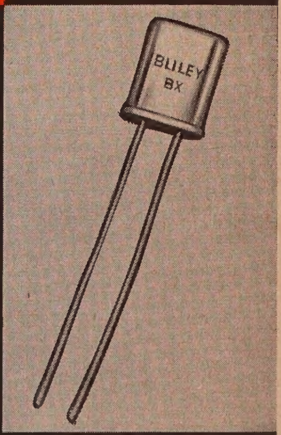


★ **CUSTOM-BUILT OSCILLATOR ASSEMBLY**



★ **BLILEY TYPE SDL-15**

★ **BLILEY TYPE TCO-1A**



★ **BLILEY BANTAM BX**

Bliley

CRYSTALS - MILITARY AND COMMERCIAL

SOLID ULTRASONIC DELAY LINES

CRYSTAL OVENS

FREQUENCY STANDARDS

CUSTOM ASSEMBLIES

COLOR TV CRYSTALS

Informative bulletins are available on all Bliley products. Write, specifying your requirement.

Bliley CRYSTALS

BLILEY ELECTRIC COMPANY
UNION STATION BLDG., ERIE, PENNSYLVANIA

for that "extra measure" of dependability

Specify

POTTER

Radio Noise Filters

especially if:

1 . . . your product reputation makes component quality the primary consideration.

2 . . . you need flexible production facilities capable of producing small runs of capacitors, engineered to fit your specific needs, quickly and economically.

Send now for this Free Catalog of the complete Potter Line.

THE **potter** COMPANY

North Chicago, Illinois, U. S. A.
Dept. E

SPECIALISTS IN FIXED PAPER CAPACITORS SINCE 1925

SOUTHERN AFFILIATE:
MICROFARADS, INC.
WESSON, MISS.

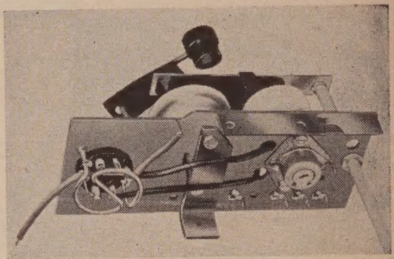
News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

(Continued from page 31A)

Transformer Bulletin

Chicago Standard Transformer Corp., Standard Div., Addison and Elston, Chicago 18, Ill., lists three New Stancor exact replacement flyback transformers for Motorola, in their Bulletin 476.

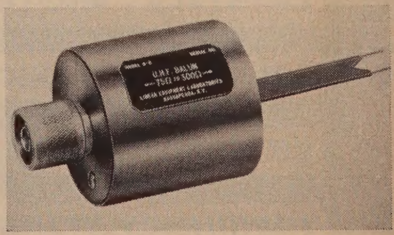


Each unit has a horizontal centering pot, variable gap-width control and a socket for a 1B3 rectifier. The original design has been improved by the addition of a corona ring on the tube socket and by the use of a linen-reinforced terminal board to withstand the strain of inserting or removing the 1B3 tube.

These three transformers cover 91 Motorola models of '52 chassis. Stancor part number A-8224 replaces Motorola flybacks 24C711265, 24C711265-A, and 24C721290 in 56 models. A-8225 replaces 24K712193 in 15 models. A8-226 replaces 24K721301C and 24K721517C in 20 models.

UHF-Transformer-Balun

A new impedance-matching device for the purpose of transforming the output impedance of an unbalanced source of voltage, such as a signal generator, noise generator or sweeper, to a balanced 300-ohm output is provided in the U-1, U-2 Transformer-Balun combination developed by **Linear Equipment Laboratories,** Brightwater Pl., Massapequa, L. I., N. Y.



Covering the 400- to 900-mc portion of the spectrum, these units are specifically designed to facilitate measurements in the uhf-TV band. The Model U-1 Transformer transforms a 50-ohm unbalanced source to 75-ohms unbalanced over the 300–900 mc range with an swr of less than 1.15. The U-2 Balun transforms a 75-ohm unbalanced source to a 300 balanced impedance over the 400- to 900-mc range with an swr of less than 1.2. Over-all swr of the combination from 400–900 mc is less than 1.2. Terminations are available for the purpose of calibrating the transformer or transformer-balun combination.

A catalog sheet is available on this unit.

(Continued on page 38A)

ERIE

Complete line of

DISC CERAMICONS ®

HIGH VOLTAGE

HIGH VOLTAGE DISC CERAMICONS employ the same basic diameters that have been standardized in 500 volt Ceramic capacitors. Careful and detailed life testing has been accomplished over a long period of time to establish required dielectric thicknesses to assure conservative ratings in the high voltage line. Standard voltage ratings range from 1,000 through 6,000 Volts, D.C., Working.

TEMPERATURE COMPENSATING

TEMPERATURE COMPENSATING DISC CERAMICONS, in four sizes, offer all standard combinations of temperature coefficient and capacitance value. They are tested for conformance to Erie specifications for Tubular Ceramicons and meet all requirements for RETMA REC-107A Class 1 ceramic capacitors. They are available in capacity ranges up to 1940 mmf.

GENERAL PURPOSE

GENERAL PURPOSE DISC CERAMICONS have low series inductance which assures efficient high frequency operation. They are made in sizes from 5/16" to 3/4" diameter, and in capacitance values ranging from 4.5 mmf to .02 mfd.

ERIE DISC CERAMICONS are available in three classes, each having a wide range of capacitance values for the basic applications. These capacitors consist of flat ceramic dielectrics with fired silver electrodes. Lead wires are firmly soldered to the electrodes, and completed units are given a protective coating of wax impregnated phenolic. For complete description and specifications, write for catalogs and samples.

ERIE components are stocked by leading electronic distributors everywhere.

TRADE **ERIE** MARK
RESISTOR CORP.

ERIE RESISTOR CORPORATION . . . ELECTRONICS DIVISION

Main Offices and Factories: **ERIE, PA.**
Sales Offices: Cliffside, N. J. • Philadelphia, Pa. • Chicago, Ill. • Detroit, Mich.
Ashland, Ohio • Fort Wayne, Ind. • Los Angeles, Calif. • Toronto, Ontario
Manufacturing Subsidiaries:
HOLLY SPRINGS, MISS. • LONDON, ENGLAND • TRENTON, ONTARIO

Eclipse-Pioneer

CORROSION-RESISTANT AUTOSYN* SYNCHROS

(AY-200 SERIES)

TYPICAL ELECTRICAL CHARACTERISTICS

	Type Number	Input Voltage Nominal Excitation	Input Current Milliamperes	Input Power Watts	Input Impedance Ohms	Stator Output Voltages Line to Line	Rotur Resistance (DC) Ohms	Stator Resistance (DC) Ohms	Maximum Error Spread Minutes
Transmitters	AY201S-26	26V, 400~, 1 ph.	125	0.6	40+j230	11.8	12	5.8	15
Control Transformers	AY201S-25	From Trans. Autosyn	Dependent Upon Circuit Design				40	10.2	20
Differentials	AY231S-25	From Trans. Autosyn	Dependent Upon Circuit Design				14	10.2	30
Resolvers	AY221S-25	26V, 400~, 1 ph.	70	0.4	108+j440	11.8	50	11.4	24

PYGMY AUTOSYN SYNCHROS

(AY-500 SERIES)

TYPICAL ELECTRICAL CHARACTERISTICS

	Type Number	Input Voltage Nominal Excitation	Input Current Milliamperes	Input Power Watts	Input Impedance Ohms	Stator Output Voltages Line to Line	Rotor Resistance (DC) Ohms	Stator Resistance (DC) Ohms	Maximum Error Spread Minutes
Transmitters	AY503-4	26V, 400~, 1 ph.	220	2.5	45+j100	11.8	23.0	11.0	24
Receivers	AY503-2	26V, 400~, 1 ph.	220	2.5	45+j100	11.8	23.0	11.0	75
Control Transformers	AY503-3	From Trans. Autosyn	Dependent Upon Circuit Design				170.0	45.0	24
	AY503-5	From Trans. Autosyn	Dependent Upon Circuit Design				550.0	188.0	30
Differentials	AY533-3	From Trans. Autosyn	Dependent Upon Circuit Design				93.0	45.0	30
Resolvers	AY523-3	26V, 400~, 1 ph.	55	0.6	290+j490	11.8	210.0	42.0	30
	AY543-5	26V, 400~, 1 ph.	11	0.12	900+j2200	11.8	560.0	165.0	30

Available for all applications is the new, *corrosion-resistant* AY-200 Series of Eclipse-Pioneer Autosyn Synchros (1.431″ dia. x 1.631″ lg.). Where space and weight are prime considerations, Eclipse-Pioneer offers the AY-500 Pygmy Autosyn Synchro Series (0.937″ dia. x 1.278″ lg.) with corrosion-resistant models available in sample quantities. Whatever your synchro requirements may be, our long experience, modern facilities and advanced production techniques can work to your advantage. For full details, write Department G.

**Registered trade-mark Bendix Aviation Corporation*

THE NAME Bendix AVIATION CORPORATION MILLIONS TRUST

ECLIPSE-PIONEER, Division of
TETERBORO, N. J.

Export Sales: Bendix International Division, 205 E. 42nd St., New York 17, N. Y.

News—New Products

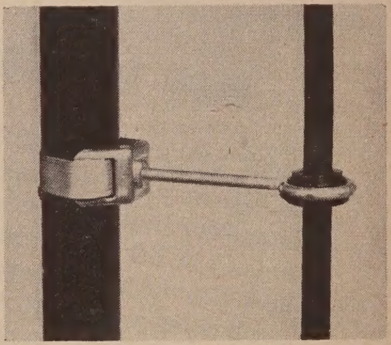
These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

(Continued from page 36A)

Stand-off Insulator

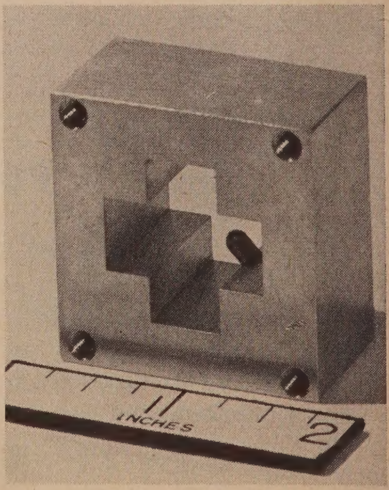
A new strap-type stand-off insulator that accommodates all standard television transmission lines is announced by the **Insuline Corp. of America,** 36-02 35th Ave., Long Island City 1, N. Y., and Manchester, N. H.

A low-loss polyethylene grommet in the eye of the device securely holds flat twin-lead ribbon, tubular twin-lead, oval-tubular lead, or coaxial cable.



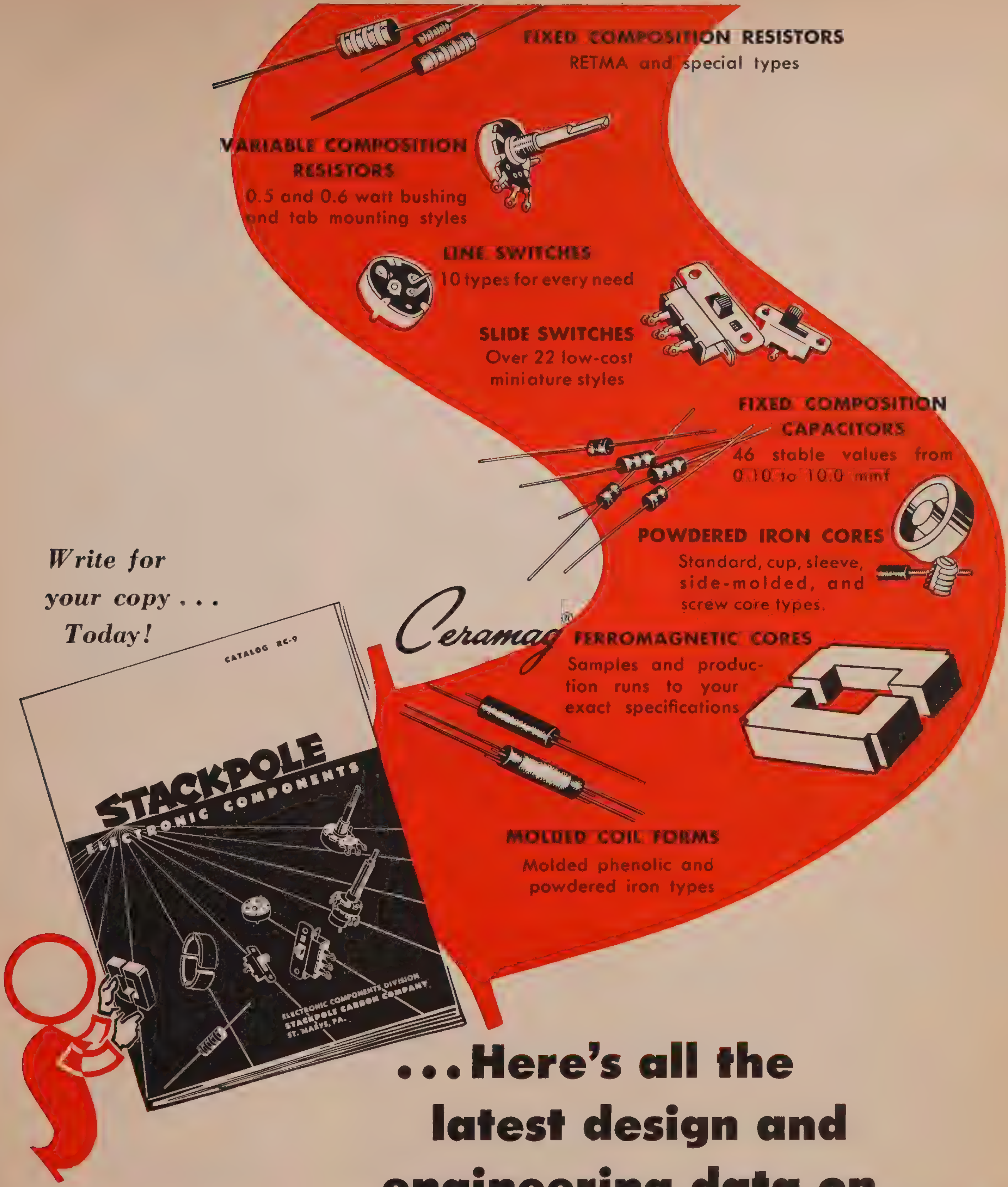
An adjustable steel strap permits the insulator to be used on pipe from $\frac{3}{4}$ inch to $1\frac{1}{2}$ inches in diameter. The assembly is tightened by means of a captive tension nut, through which the threaded end of the insulator screw eye passes. All metal surfaces are zinc plated.

Microwave Components



General Precision Laboratory, Inc., 63 Bedford Rd., Pleasantville, N. Y., announces a new broad band impedance matched 90° short twist for X-band in RG-52/U waveguide size. The tapped holes in twist block faces will determine the angular orientation of the mating UG-40A/U choke flange terminated waveguides, so that these members will be at 90° to one another. Units are impedance matched to afford a VSWR less than 1.22 from 8500 to 9500 mc.

(Continued on page 44A)


CATALOG RC-9
STACKPOLE
ELECTRONIC COMPONENTS
ELECTRONIC COMPONENTS DIVISION
STACKPOLE CARBON COMPANY
ST. MARYS, PA.

FIXED COMPOSITION RESISTORS
RETMA and special types

VARIABLE COMPOSITION RESISTORS
0.5 and 0.6 watt bushing and tab mounting styles

LINE SWITCHES
10 types for every need

SLIDE SWITCHES
Over 22 low-cost miniature styles

FIXED COMPOSITION CAPACITORS
46 stable values from 0.10 to 10.0 mmf

POWDERED IRON CORES
Standard, cup, sleeve, side-molded, and screw core types.

Ceramag® **FERROMAGNETIC CORES**
Samples and production runs to your exact specifications

MOLDED COIL FORMS
Molded phenolic and powdered iron types

Write for your copy . . . Today!

. . . Here's all the latest design and engineering data on

STACKPOLE COMPONENTS!

Write for the new 56-page Stackpole Catalog RC-9 for complete charts, graphs, formulas, and detailed specifications on these dependable components.

Electronic Components Division
STACKPOLE CARBON COMPANY, *St. Marys, Pa.*

... Complete line of Microwave Components from magnetron to antenna ...
designed and produced by experts—

WAVEGUIDE SWITCH
A complete line; compact, rugged, suitable for military usage; VSWR less than 1.10; crosstalk greater than 50 Db; operation 24 v. DC, 110 v. AC; may be specially designed to meet switching problems.

MIXER DUPLEXER
Precision-built to closest tolerances; completely tested. Designed to meet your basic requirements, or produced from your blueprints.

DUMMY LOADS
Designed for military field operation; built to meet all standard military vibrations and shock requirements. Capable of operating at extremely high average powers.

FLEXAGUIDE
Pressure-tight; rugged enough to meet roughest requirements; VSWR less than 1.10; attenuation equal to brass rigid guide.

COUPLERS
Complete series for all waveguide sizes. Flange combination, and waveguide or coaxial outputs. Designed to meet your particular problems.

For RIGID Waveguide Specify
GUIDELINE
Rigid Bends • Twists • Tapers • Crystal Mixers • Duplexers
Flanges • Magic Tees • Directional Couplers • Dummy Loads
Waveguide Switches • Coax Adaptors • Precision Castings
Waveguide Transformers • Quick Disconnect Clamps

For FLEXIBLE Waveguide Specify
FLEXAGUIDE
Army and Navy Standard Waveguides
Flexible Twists • Bends • Tapers
Straight Sections • All Lengths and Sizes

Write for Catalogs

Airtron inc.
Linden, New Jersey

BRANCH OFFICES
DAYTON CHICAGO LOS ANGELES DALLAS
KANSAS CITY SEATTLE ALBUQUERQUE

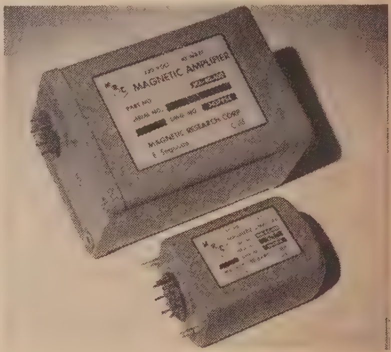
News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

(Continued from page 44A)

Magnetic Amplifiers

Magnetic Research Corp., Dept. FW, 318 Kansas St., El Segundo, Calif., has developed several Magnetic Amplifiers for standard 400 cps servo motors. The amplifiers are especially designed to meet high temperature requirements. No rectifiers are used. The output wave form is sinusoidal, 400 cps ac, phase reversing, corresponding to the input. Input signal may be ac or dc. All models are controlled by a 12AU7 type tube which also serves as a demodulator for ac input signals. The amplifiers are hermetically sealed to MIL-T-27 specifications.



Model #MA-3.5-400 delivers 3.5 watts, 115 volts, and is designed for servo motors such as U. S. Navy Model MK14 Model 0. The frequency response of this amplifier is from 0 to 55 cps. The unit is housed in a GP-4 deep drawn steel can with a 7 pin phenolic header. The weight is 12 ounces. It can be operated continuously at an ambient temperature of 105°C.

Model #MA-15-400 has similar specifications except that it is rated for 15 watts output.

Model #MA-40-400 is a 40 watt unit delivering 220 volts. It is designed for servo motors such as an Eclipse Pioneer CK 3001. The frequency response of this unit is from 0 to 10 cps. The unit is housed in a MIL-T-27 HA can with a 7 pin phenolic header. The weight is 4 pounds, 2 ounces, and it can be operated at an environmental temperature at 75°C.

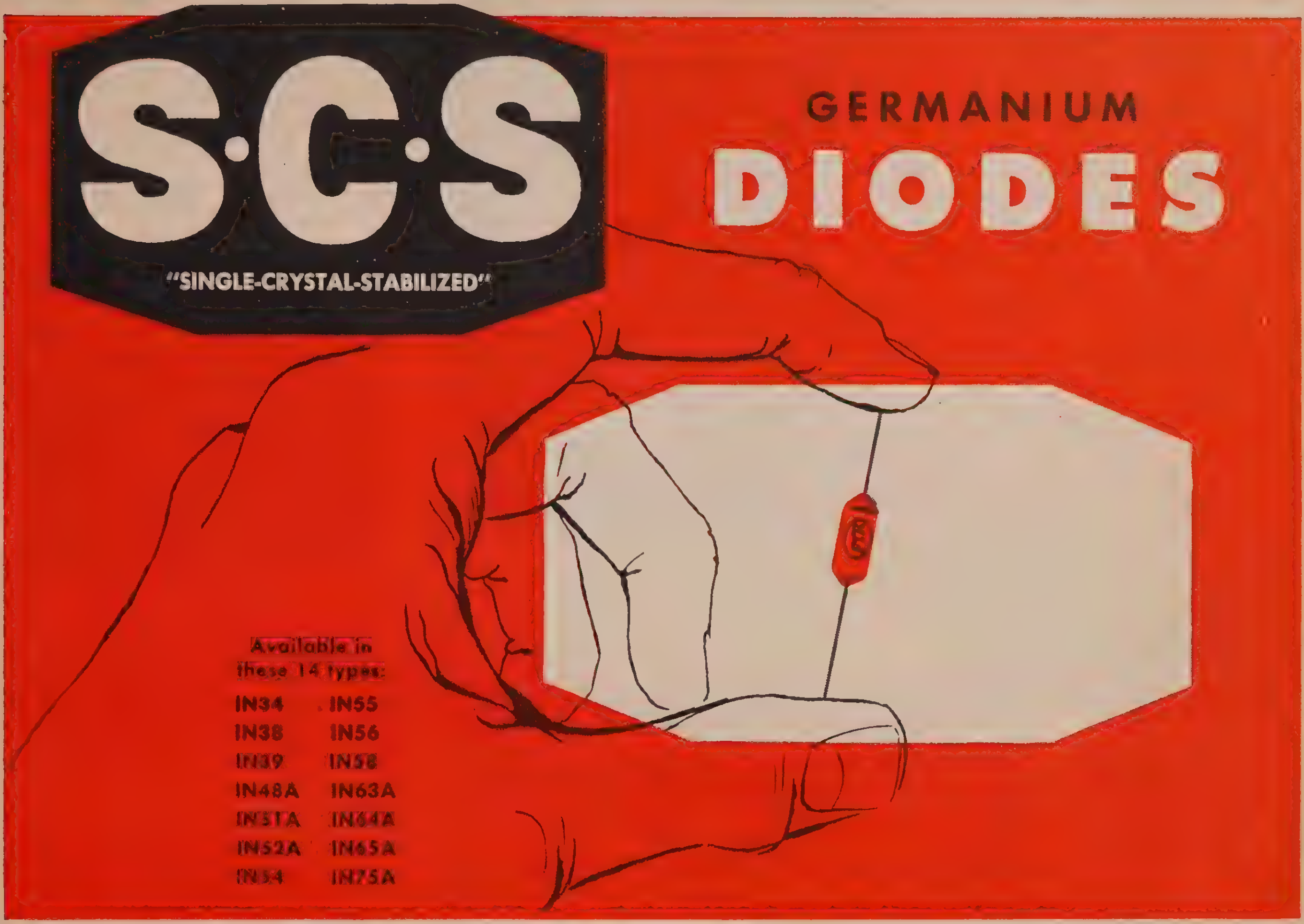
Amateur Single Side Band Filters

As a recent addition to its new series of single side band filters, **Burnell & Co.,** 45 Warburton Ave., Yonkers 2, N. Y., announces the release of an economical side band filter that will appeal to amateur users and manufacturers of low cost commercial side band receivers. The type S-15,000 consists of stabilized toroids and other high quality components that will attenuate a 50 kc carrier at 20 db, and most of the upper side band 40 db. Audio response through the filter would be 300 to 3,300 cps. Additional information is available upon request.

(Continued on page 58A)

Announcing another outstanding

DESIGN ACHIEVEMENT by *Federal*



S·C·S

"SINGLE-CRYSTAL-STABILIZED"

GERMANIUM

DIODES

Available in these 14 types:

IN34
IN38
IN39
IN48A
IN51A
IN52A
IN54
IN55
IN56
IN58
IN63A
IN64A
IN65A
IN75A

CHECK THESE FEATURES—

- **SINGLE-CRYSTAL GERMANIUM**—the finest for reliable performance
- **MOISTURE-PROOF**—vacuum-sealed, all-ceramic construction to provide stable characteristics
- **EVERY DIODE TESTED** for all characteristics, including oscilloscope tests for hysteresis and non-linearity
- **COMPLETELY INSULATED CASE**
- **POLARITY** clearly identified
- **HEAT SINKS** protect during soldering
- **SMALL SIZE** (—¼″ diameter, ½″ long)
- **FLEXIBLE LEADS** for easy mounting
- **NO FILAMENT**—no heater power drain or hum
- **LOW SHUNT CAPACITY** (average 1 mmf.)
- **SELF-HEALING** for temporary overloads
- **NO CONTACT POTENTIAL**
- **WITHSTANDS** adverse temperature and humidity cycling

"SINGLE-CRYSTAL-STABILIZED"

...precision-made and vacuum-sealed to provide a new high in performance for germanium diode applications!

Product designers! Now it's Federal's new *single-crystal-stabilized* diodes . . . bringing to you high-quality single-crystal germanium for the utmost in reliable performance, combined with a construction to provide stable operation over long hours of use.

Federal "S-C-S" Diodes are vacuum-sealed . . . solidly encased in a non-porous ceramic that firmly bonds both ends to case and leads, resulting in *moisture-proof* construction.

Federal "S-C-S" Diodes withstand repeated temperature and humidity cycling—without adverse effect on their electrical characteristics. Their small size, fully insulated case and flexible leads permit fast, easy mounting in all types of equipment.

Get all the facts about Federal "S-C-S" Diodes . . . a notable contribution to diode progress . . . insuring tens of thousands of hours of dependable performance!

FEDERAL TELEPHONE & RADIO
FTR
DIVISION OF IT&T

Federal Telephone and Radio Company

SELENIUM-INTELIN DEPARTMENT **100 KINGSLAND ROAD, CLIFTON, N. J.**

In Canada: Federal Electric Manufacturing Company, Ltd., Montreal, P. Q.
Export Distributors: International Standard Electric Corp., 67 Broad St., N. Y.

For details on Federal "S-C-S" Diodes, write to Dept. R-137.

Immediate Delivery

THE NEW **HYCOR** 700 SERIES

DECADE-INDUCTOR UNITS

- HYCOR Decade-Inductor Units are indispensable for design and experimentation work on audio filters.
- The units are available in four ranges up to 10 henries. Units may be used individually or all four may be connected in series to obtain 11.11 henries in 1 millihenry steps.
- Toroid coils are used to obtain HIGH "Q" stability and LOW PICKUP from external fields. Inductance accuracy is 2%.

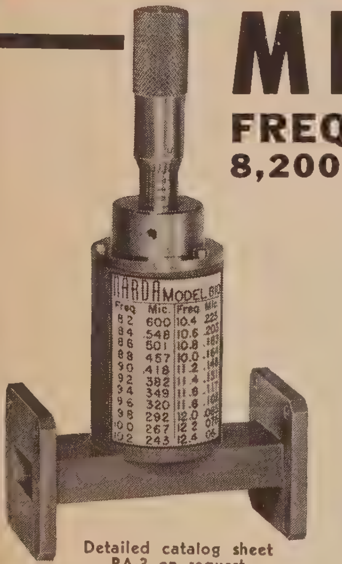
Send for Bulletin D-2 for specifications and prices.

HYCOR SALES COMPANY of California

Representatives:
Beebe Associates, 115 Waukegan Rd., Glenview, Illinois
Burlingame Associates, 103 Lafayette St., New York City
Harrison J. Blind, 1616 Cord St., Indianapolis 24, Indiana
G. M. Howard & Assoc., 734 Bryant St., San Francisco 7, Calif.

11423 VANOWEN STREET • NORTH HOLLYWOOD, CALIF.

MICROWAVE FREQUENCY METER 810
8,200 mc to 12,400 mc



The NARDA model 810 Frequency Meter is a cylindrical cavity type resonator mounted on a section of 1 x ½ waveguide · The cavity is tuned over the complete range by a precision micrometer drive with a vernier which may be read to 0.0001 inch · A calibration table is mounted on the cavity · A reactive dip of at least 10% is obtained at all frequencies in the range · There are no spurious responses or other ambiguities.

SPECIFICATIONS:

Accuracy:	0.1%	$110.00 FOB.
Precision:	0.02%	
Loaded Q:	7000	
Reactive dip:	10% min.	

NEW IMPROVED BOLOMETERS

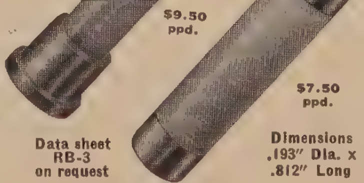
Detailed catalog sheet RA-3 on request

APPLICATIONS:
Microwave power measurement · Square Law detection · VSWR detection · Attenuator calibration.

FEATURES:
N-610B INTERCHANGEABLE with IN21 and IN23 crystals in all tuneable probes, waveguide and coaxial crystal detectors.
STANDARDIZED BIAS—8.75 ma. for 200 ohms.
HIGHER BURNOUT RATING—15 mw of rf at rated bias.
RUGGEDIZED—soldered contacts and improved construction.
N-821B INTERCHANGEABLE in all barretter mounts.
RUGGEDIZED CONSTRUCTION.
Silver contacts and continuous copolymerstyrene sleeve.
STANDARDIZED BIAS—8.75 ma for 200 ohms.

MODEL N-610B $9.50 ppd.

MODEL N-821B $7.50 ppd.



Data sheet RB-3 on request

Dimensions .193" Dia. x .812" Long

Write for NARDA Catalog RC-3—a COMPLETE line of microwave test equipment.

NARDA NASSAU RESEARCH & DEVELOPMENT ASSOCIATES INCORPORATED
66 MAIN STREET · MINEOLA, NEW YORK · GARDEN CITY 3-3570

News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

(Continued from page 50A)

Production Tester

Completed electronic or electrical products are production-line tested at the rate of several checks per second with a new Supertester, manufactured by **Color Television Inc.**, 974 San Carlos Ave., San Carlos, Calif. This automatic quality-control instrument provides facilities in a standard model for as many as 400 individual automatic sequenced tests.

The tests themselves can be distributed as required among the following six basic types: continuity, leakage, dc voltage, ac voltage, resistance, and impedance. In addition, derivative characteristics such as gain, frequency response, phase relationships, and noise levels are determined automatically through the combination of two or more of the standard tests. Circuity is included to allow manual dialing to any one of the tests at will.

Facilities are also provided for utilizing accessory signal generators, dropping resistors, and so forth to permit tests at frequencies or voltages outside the scope of the standard instrument.

Flexibility and rapid interchange between different setups are the objectives of the dual-unit design of the instrument. The master cabinet (at bottom in illustration) contains the basic switching units and electronic measuring circuits. No internal changes or adjustments are required for any test sequence. Adapters, which are plugged into the top of the master unit, are individually laid out and wired to meet the requirements of each particular type of production equipment under test.

Transistor Batteries Bulletin

Burgess Battery Co., Freeport, Ill., has recently published a four-page folder covering its developments in the field of transistor batteries. The folders are available on request.

The folder describes the requirements for batteries used in transistor circuit operation. Graphs are used to show the performance of the batteries in comparison to other types and makes. Typical batteries now being used by transistor engineers are illustrated and described. Write Transistor Engineers, Burgess Battery Co. for a copy.

(Continued on page 82A)

PROCEEDINGS OF THE I·R·E®

Published Monthly by

The Institute of Radio Engineers, Inc.

VOLUME 42 *April, 1954* NUMBER 4

THE PROCEEDINGS OF THE I.R.E.

Axel G. Jensen, Director, 1954 656

THE PROCEEDINGS OF THE I.R.E. .... John R. Pierce 657

4904. IRE—Past and Future .... Alfred N. Goldsmith 658

4905. Temperature-Compensated DC Transistor Amplifier .... Edward Keonjian 661

4906. Design of RC Wide-Band 90-Degree Phase-Difference Network. .... Donald K. Weaver, Jr. 671

4907. Ultra-Low-Frequency, Three-Phase Oscillator .... Gilbert Smiley 677

4908. A Method of Solving Very Large Physical Systems in Easy Stages .... Gabriel Kron 680

4909. Radiation Resistance and Gain of Homogeneous Ring Quasi-Array .... H. L. Knudsen 686

4910. A Stable Voltage-Controlled Logarithmic Attenuator .... Gail E. Boggs 696

4911. Geometric Aspects of Least Squares Smoothing .... Arthur A. Hauser, Jr. 701

4912. Radio Progress During 1953 705

Correspondence:

4913. "Silicon *P-N* Junction Power Rectifiers and Lightning Protectors" .... G. L. Pearson and C. S. Fuller 760

Contributors to the PROCEEDINGS OF THE I.R.E. 761

IRE NEWS AND RADIO NOTES SECTION

1954 NEREM to Be Held in May 762

National Airbourne Electronics Conference 763

Technical Committee Notes 764

Professional Group News 765

IRE People 766

Books:

4914. "High Fidelity Techniques" by John H. Newitt .... reviewed by John K. Hilliard 767

4915. "Practical Television Engineering—Second Edition" by Scott Helt .... reviewed by Donald G. Fink 767

4916. "Electron Optics" by O. Klemperer .... reviewed by S. G. Ellis 768

4917. "Principles of Modern Acoustics" by George W. Swenson, Jr. .... reviewed by Benjamin B. Bauer 768

4918. "Information Theory—and Its Engineering Applications" by D. A. Bell .... reviewed by Nathan Marchand 768

4919. Abstracts and References 769

Meetings with Exhibits 2A

News—New Products 24A

Industrial Engineering Notes .. 66A

Professional Group Meetings .. 76A

Section Meetings 85A

Student Branch Meetings 92A

Membership 98A

Positions Open 112A

Positions Wanted 114A

Advertising Index 150A

Copyright 1954, by the Institute of Radio Engineers, Inc.

BOARD OF DIRECTORS, 1954

William R. Hewlett
President

M. J. H. Ponte
Vice-President

W. R. G. Baker
Treasurer

Haraden Pratt
Secretary

John R. Pierce
Editor

D. B. Sinclair
Senior Past President

J. W. McRae
Junior Past President

1954
A. N. Goldsmith
J. T. Henderson (R8)
A. V. Loughren
C. A. Priest (R4)
J. R. Ragazzini (R2)
J. D. Ryder
A. W. Straiton (R6)
J. A. Stratton
Ernst Weber

1954–1955
S. L. Bailey
C. J. Marshall (R5)
L. E. Packard (R1)
J. M. Pettit (R7)
B. E. Shackelford
H. W. Wells (R3)

1954–1956
A. G. Jensen
George Rappaport

●

George W. Bailey
Executive Secretary

●

John B. Buckley
Chief Accountant

Laurence G. Cumming
Technical Secretary

Evelyn Davis
Assistant to the Executive Secretary

Emily Sirjane
Office Manager

Responsibility for the contents of papers published in the PROCEEDINGS OF THE I.R.E. rests upon the authors. Statements made in papers are not binding on the Institute or its members.

EDITORIAL DEPARTMENT

Alfred N. Goldsmith
Editor Emeritus

John R. Pierce
Editor

E. K. Gannett
Managing Editor

Marita D. Sands
Assistant Editor

●

ADVERTISING DEPARTMENT

William C. Copp
Advertising Manager

Lillian Petranek
Assistant Advertising Manager

●

EDITORIAL BOARD

John R. Pierce
Chairman

Changes of address (with advance notice of fifteen days) and communications regarding subscriptions and payments should be mailed to the Secretary of the Institute, at 450 Ahnaip St., Menasha, Wisconsin, or 1 East 79 Street, New York 21, N. Y.

All rights of publication, including translation into foreign languages, are reserved by the Institute. Abstracts of papers with mention of their source may be printed. Requests for republication privileges should be addressed to The Institute of Radio Engineers.

Axel G. Jensen

Director, 1954

Axel G. Jensen was born on February 7, 1896 in Copenhagen, Denmark, and was graduated in 1920 from the Royal Technical College in that city. On receiving his degree in Electrical Engineering, he remained there for a year as an instructor. He then came to America to do post-graduate work at Columbia University. In 1922 he joined the Western Electric Company's Engineering Department which later became known as Bell Telephone Laboratories. From 1922 to 1926, Mr. Jensen was engaged in radio receiving studies and in the design of field strength measuring sets. He spent the next five years in London, in charge of the test station operated during development of transatlantic short wave service. In 1930 he returned to the United States to work on coaxial cable system projects, and was in charge of the development of terminal and measuring equipment for telephone and television. In 1938 he became Research Engineer in charge of television research at Bell Telephone Laboratories, and since 1952 has been Director of Television Research. He holds a number of patents, and is the author of numerous technical articles.

Mr. Jensen joined the IRE as an Associate in 1923, became a Member in 1926, and a Fellow in 1942. He has served on several IRE committees, including among others, the Audio and Video Techniques Committee, and the Television Facsimile Committee. From 1948 to 1951 he served as Chairman of the IRE Television Systems Committee, and since 1951 has been Chairman of the Standards Committee. He holds the office of Director-at-Large for the term 1954–1956.

Mr. Jensen is a Fellow of the Society of Motion Picture and Television Engineers, and is presently serving as Engineering Vice-President of the Society. In 1952 he was awarded the G. A. Hagemann Gold Medal for Industrial Research from the Royal Technical College in Copenhagen. In the same year he was also awarded the David Sarnoff Gold Medal by the Society of Motion Picture and Television Engineers in recognition of his work in television research.

The Proceedings of the I.R.E.

JOHN R. PIERCE, EDITOR

Any statement of policy by a new Editor concerning so venerable and distinguished a journal as the PROCEEDINGS OF THE I.R.E. must in a large measure merely reiterate the policy which has guided our Editor Emeritus in the long years through which he formed and developed that publication. Nonetheless, it is perhaps well from time to time for the members of the Institute to consider the PROCEEDINGS and its purposes.

The PROCEEDINGS should especially publish as promptly as possible papers describing new technical advances of such importance that they are of general interest. These advances may be new inventions, new systems, new theories, new measurements, new calculations: anything in the field which is new and important. A paper describing such work must of course contain sound technical substance, mathematical or otherwise, but such a paper will be most valuable if it explains clearly the importance and nature of the advance which has been made, and if it tells simply how to use any equations or curves which may be presented.

We will endeavor to see that such papers receive prompt and expert editorial treatment, and to suggest cuts or changes only to remedy particular defects which the reviewers find.

Prospective authors will be interested to read our instructions to reviewers, which are reprinted on page 764 of this issue under the title, "Reviewing Papers for the PROCEEDINGS OF THE I.R.E."

Sometimes the essence of a new advance can be expressed in a few hundred words, with few or no illustrations, so that it can be described in a letter to the editor. Such letters will receive special consideration for immediate publication.

Often, sound work of a very high quality, work of great importance in a special field, may be so specialized as to be of little interest to people outside of that field. In general, we believe that such work should be published in the TRANSACTIONS of some one of the Professional Groups rather than in the PROCEEDINGS. A recommendation so to publish is no reflection on the quality of a paper, but represents merely a judgment as to its interest for the general membership of the Institute.

Besides contributed technical papers, the PROCEEDINGS publishes from time to time tutorial papers, which are intended to teach the use of modern techniques in solving problems in various fields, and review papers, which are intended to give a picture of the state of the art in various fields. The PROCEEDINGS also publishes book reviews, editorials, news and other material. These other subjects will be dealt with in future issues.

To handle all of these matters well we must have the co-operation of authors in preparing their material well, and that of readers in making suggestions and in criticizing our efforts, as we solicit them to do.

IRE—Past and Future*

ALFRED N. GOLDSMITH, EDITOR EMERITUS AND FELLOW, IRE

FELLOW DIRECTORS and Officers of the Institute, Honored Guests, my fellow members and friends, ladies and gentlemen:

Although I earnestly hope and confidently expect to join with you for many years on this and similar occasions, and steadily to continue to give our Institute the best services of which I am capable, this particular moment is in a sense the end of an epoch for me. It has been an era of glowing opportunities and rich rewards, for both of which I am deeply grateful. It is therefore becoming for me first to render to you a brief accounting of my stewardship of over more than forty years. In my case, this is a pleasant obligation of a long-term official.

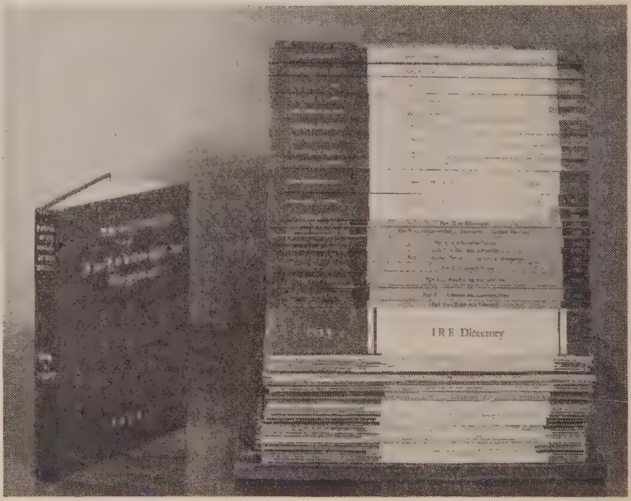
While statistics are often dry, those describing the growth of the editorial activities of our Institute are startling and stimulating. Accordingly I venture to present a few facts and figures to you. In terms of today's size of page, the total PROCEEDINGS content for 1913 was 124 pages. For 1953, it was 4,006 pages, or 32.3 times as great. But, added to this, the 1953 IRE CONVENTION RECORD had 1,272 pages. And the 1953 TRANSACTIONS of the various Professional Groups totaled 1,798 pages. To these are also added the 1,048 pages of the 1953 IRE DIRECTORY, plus a number of special technical publications. The grand total for 1953 IRE publications reached the impressive total of 8,360 pages, or 67.6 times the 1913 publications!

But more important than bulk is the encouraging fact that the over-all technical quality, and the general usefulness of IRE publications to the membership, have grown steadily over the years. Truly, we are members of no mean Society.

Since inherent value has been maintained, we are justified in comparing, by volume, the 1913 PROCEEDINGS OF THE I.R.E. with the corresponding 1953 PROCEEDINGS and other IRE publications. Under the influence of certain television commercials, I may describe the latter as "So large, so clear, so data-packed, so helpful to the brain. And its information is RIGHT too!!"

I have the further and pleasant opportunity of gratefully acknowledging the unswerving and intelligent support and guidance which I have received from many groups and individuals in our Institute. These include Harold P. Westman who devoted much constructive and fruitful thought to the upbuilding of the PROCEEDINGS, Helen M. Stote whose constant and loyal endeavors were most helpful, Clinton DeSoto who effectively carried forward the progress of our publications, and, of course, Elwood K. Gannett whose indefatigable and capable labors have merited the recognition he has received. These hard-working and indispensable people were and are but little known to the membership which nevertheless owes them a debt of gratitude.

But beyond these editorial workers, I must express further deep appreciation of the unfailing confidence, support, and advice I have received from many Boards of Directors who proved to be exceptionally intelligent and co-operative leaders; to the Executive Committees which invariably included many consistently thorough and hard-working members; and to our Executive Secretary, George W. Bailey, who has been a tower of strength and intelligent co-operation over the years.



An example of IRE's growth is indicated in the picture above. (*left*) All publications for the year 1913, bound in a single volume. (*right*) In contrast, unbound output of 1953's publications.

As you will gather, the decades of my Editorship were somewhat stormy and always demanding. Indeed, my only comparatively peaceful year since the beginning of our Institute was that during which I was the IRE President. Fortunately this came at a time when the President could spend a relatively placid and almost sabbatical year—a condition since altered with the coming of far heavier demands on the Presidential time and energy.

In considering the various honors which it has pleased the Board of Directors recently to confer on me, I have some pleasant thoughts which I wish to share with my friends here.

The unique title of Editor Emeritus is one which confers not only dignity but the implication of merit. While only you can judge the degree of true merit which it contains yet I certainly hope that that measure of merit at least approaches the overflowing measure of gratification and hope of accomplishment which the Editorship has always carried for me.

---

* Presented at the IRE Annual Banquet, New York, N. Y.; March 24, 1954.

I shall particularly value the Founders Award as a spontaneous expression of the regard of my fellow Directors. I also felt especially honored and pleased by the fact that my illustrious predecessor for this Award was my good friend, General David Sarnoff. I believe both he and I feel that the present high repute and multitudinous accomplishment of the Institute are in themselves another and most gratifying Founders Award.

The Board of Directors has suggested to its successors that I be included in their fine roster. This I regard as at once a most challenging opportunity and a binding duty for me. My future Board membership should afford me a rare opportunity of continuing to work with the leaders of the Institute and contributing to their policies and decisions. Reciprocally, I have offered my aid in any "dire emergency"—although I hope and believe that our Institute will have only "undire" emergencies.

You may therefore gather, as I do, that this occasion is for me not a "graduation" but rather a "commencement." The Institute direction is so virile and vigorous that it has not failed to stimulate in me many thoughts and what I hope will be constructive contributions. It is as yet too early to lay certain of these basic and humanly important ideas before you.

The 1954 Editorial setup of our Institute may be briefly described, as a matter of general information to you. It has really evolved from earlier and successful organizations. The new Editorial Board is a streamlined version of the Editorial Administrative Committee which has been in useful operation for a number of years. It will presumably concentrate more closely on policy questions and less on operational matters. The papers review procedure is little changed except that it is abridged, and more dependence will probably be placed on routine decisions by a member of the Institute staff, namely the Managing Editor. The setup is obviously geared toward greater dependence on the headquarters staff for daily operations under the policy guidance of the Editorial Board. An unusually capable group of "younger statesmen" has been selected for this Board. To them go my best wishes for their consistent success.

Greatly to my gratification, I have been asked to remain in touch with major editorial policies and operations and to be available in emergencies. Fortunately for me at least, my connection with these matters will be informal. I feel that I have thus succeeded in the aim of every competent executive of working myself out of as many organized jobs as possible and of having provided as many attractive opportunities for others as may be feasible. And in any case, I am grimly determined not to be a combined proverbial back-seat driver and father-in-law.

If I may reminisce for a few moments, I should like briefly to describe for your edification some of the problems of an editor and my fairly seasoned viewpoint as to how these problems may be met.

First, here are some of your Editor's (and Managing Editor's) problems.

The Editor must of course be quick to recognize the need for papers of a particular type or subject matter, and must determinedly seek them in the right quarters. He must learn rarely to accept refusals from a suitable prospective author even at the cost of occasional acidulated comments. He must encourage careful and clear writing, and return for revision manuscripts not meeting this criterion. Some of the material submitted to the Institute is stated to be, for the moment, in confidence. In general, the Editor should discourage this embarrassing and hampering practice. He must face the fact that some topics are inherently controversial or are belligerently presented. Here cool and analytic presentation should be substituted—and always with personalities eliminated. The legitimate ambitions of corporations and other bodies must be recognized but not at the cost of accuracy of statement or lack of objective presentation. Then too, personal incompatibilities crop up only too often, and allowance must be made for them and corrective measures applied. Priority claims sometimes present puzzling situations solvable only by a rigidly judicial and impersonal viewpoint. Beyond all the preceding, issues of a journal should, within reason, offer a "balanced diet" of selected topics. And even advertising must be watched lest unethical or misleading statements creep in. All of these matters have come up in the past, and the methods and results of their effective handling have been embodied in our "Editorial Policy Manual," which compendium should continue with revisions to prove to be a useful everyday guide.

It must be admitted that the editorial problems are legion and that they must be tolerated and thoughtfully handled to the limit of endurance—and sometimes beyond.

Over the years, an Editor can give himself some much-needed advice. Some of his self-guides are the following. In the first place, for a successful and attractive publication, nothing is constant but change. An unchanging pattern commands diminishing interest. Yet violent surges of change must be controlled, and for them should be substituted a steadily rising line of progress. Accordingly, while sights should be raised from time to time, changes in the field of view should not be too rapid. Further, the Editor must have his finger on the pulse of the readers. This requires a combination of information as to their wishes and intuition on his own part.

Editing should be a democratic procedure largely based on reader needs and desires. Yet the Editor must always insist on the dignified position and definite value of his expert advisers and must endeavor to anticipate reader requirements and to raise standards somewhat above those currently accepted. On the whole, editing is an empirical task and calls for intuition to a greater extent than many have believed. Long-term vision often serves better than presently available data. To digress for a moment, may I quote two great scientists on the importance of the intuitive process. Albert Einstein has expressed the following views:

> "I believe in intuition and inspiration. . . . At times I feel certain I am right while not knowing the reason. . . . Imagination is more important than knowledge. For knowledge is limited, whereas imagination embraces the entire world, stimulating progress, giving birth to evolution. It is, strictly speaking, a real factor in scientific research."

And Dr. Irving Langmuir made the following illuminating comment on intuition:

> "In the complicated situations of life we have to solve numerous problems and make many decisions. It is absurd to think that reason should be our guide in all cases. Reason is too slow and too difficult. We do not have the necessary data or we cannot simplify our problem sufficiently to apply the methods of reasoning. What then must we do? Why not do what the human race always has done—use the abilities we have—use common sense, judgment, and experience. We underrate the importance of intuition.
>
> "In almost every scientific problem which I have succeeded in solving, even after those that have taken days or months of work, the final solution has come to my mind in a fraction of a second by a process which is not consciously one of reasoning. Such intuitive ideas are often wrong. The good must be weeded out from the bad—sometimes by common sense or judgment—other times by reasoning. The power of the human mind is far more remarkable than one ordinarily thinks. We often size up a situation, or judge the character of a man by the expression of his face or by his acts in a way that would be quite impossible to describe in words.
>
> "People differ greatly in their ability to reach correct conclusions by such methods. . . ."

Among the sometimes confusing events the Editor may encounter are these. He will receive impassioned and lengthy letters urging the Institute to do what it actually is doing. In the same mail, he will find letters strongly urging a given course of conduct and others as vigorously demanding the opposite. And, perhaps most difficult of all, he will receive letters from high idealists proposing worthy measures wholly beyond the financial or manpower resources of the Institute. Here he must temper sympathy with practicality.

Naturally, complete impartiality is needed in editorial decision. One workable policy is to dissatisfy all complaining readers equally—*but* not to dissatisfy them too much. Then too, these decisions must be based on a well-adjusted balance of long-term vision and the speedy action needed to keep the Institute a successful "going concern." And the Editor must be unusually tenacious of purpose, remembering a well-known decision of a Canadian court that "A good watchdog does not let out a few yelps and then run behind the barn. He keeps on barking until something happens."

Our Institute and its Editorial Department have always been fortunate in that they were concerned with an extraordinarily vital field of human endeavor, rapidly advancing in stimulating fashion. The communications and electronic field is an unusually interesting and humanly valuable one. Its past has enabled it to make great contributions both to the public welfare and to national defense. It has even greater and more inspiring future prospects. Even if there were much more available time, it would be impossible for me to outline the many directions in which progress may come in our domain. But a few brief and incomplete examples may be in order. The role of electronics in industry will steadily widen. Manufacturing and production, handling, storing, retailing, accounting, and billing will all draw heavily on electronics. Mass communication to the home and to vehicles will expand until tomorrow's color television will be only the foreshadowing of some even more comprehensive system of the future. Nor will the home see electronics only in the form of broadcast reception. Electronics will be applied to home cooking, refrigeration, air conditioning, cleaning, advanced lighting, and heating. And perhaps even acoustic silencing may be based on electronics. There is also a reasonable prospect that the atomic battery will evolve into a large-scale and highly effective electronic device both in the home and elsewhere. Jumping from the home to the universe, radio astronomy shows real promise of rivaling its optical predecessor in giving man detailed knowledge of the vast and amazing universe in which he finds himself. Perhaps radio astronomy will also serve ultimately as a means of interplanetary guidance and protection for the intrepid space travelers of a distant day. In a more mundane field, economic studies and other analyses of the ordered or random behavior of man will be carried out by elaborate computers, which might equally well be applied to the precise prediction of the weather—"a consummation devoutly to be wished." It may be that the greatest triumphs of electronics in a human sense will come in the field of medicine where electron microscopy and its successors, namely, exquisitely delicate and informative instrumentation, accurate diagnostic devices, and appropriate methods of electronic physiotherapy may contribute greatly to the health, comfort, and length of life of man.

It is significant that the scope of the work of the radio engineer has widened to the entire universe and narrowed to the tiniest fragment of matter. Detailed predictions of the future are of course unavailable. But of this we may be sure: He who reads (or else electronically absorbs) our PROCEEDINGS OF THE I.R.E. and our IRE Professional Group TRANSACTIONS for January of the year 2000 is to be envied. Vistas unbelievable and unimaginable to us will there be unfolded before him. Our

Institute has a great heritage from the past and a vaster prospect for the future. Its success is the result of the integrated efforts of tens of thousands of men over decades. It is one of the most striking examples of rugged individualism combined with self-discipline and the professional spirit giving birth to a directed and overwhelming force. Our Institute is thus a bright omen of the possibility of fullest and most effective co-operation within the framework of democratic operation and, I may add, republican administration. With these great agencies at our disposal, we can accomplish what we will. As Sir Frederick Banting said:

> "It is not within the power of the properly constructed human mind to be satisfied. Progress would cease if this were the case. The greatest joy of life is to accomplish. It is the getting, not the having. It is the giving, not the keeping.
>
> "I am a firm believer in the theory that you can do or be anything you wish in this world, within reason, if you are prepared to make the sacrifices, think and work hard enough and long enough."

And so the torch is in your hands; the future within your grasp. My thanks and best hopes to you, my colleagues and friends.

Temperature-Compensated DC Transistor Amplifier*

EDWARD KEONJIAN†, SENIOR MEMBER, IRE

Summary—**The operation of a dc transistor amplifier is greatly affected by drift of the output current.**

This drift is caused primarily by changes of temperature of transistors since some of the parameters of transistors, like the collector current for zero emitter current, I_{co}, are very sensitive to temperature.

In this paper the problem of the drift in dc transistor amplifiers, caused by changes of temperature, is analyzed and different methods for the solution of this problem are recommended.

One of these methods, which provides an effective means for compensation, is based on the use of temperature-sensitive resistors as a compensating element. The second part of this paper contains operating characteristics of such an experimental dc amplifier, employing this method of temperature compensation.

THE PROBLEM OF DRIFT IN DC TRANSISTOR AMPLIFIERS

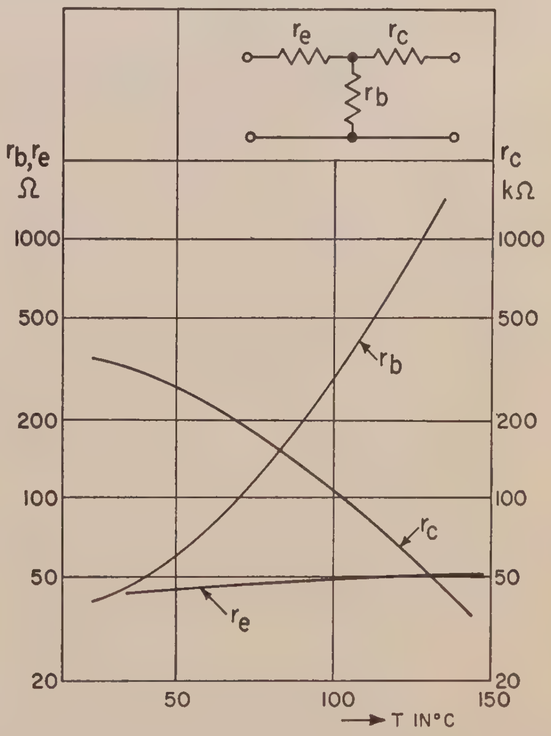


Fig. 1—Variation of transistor parameters.

THE USE OF dc transistor amplifiers at the present state of the transistor art is very much impeded by the considerable drift in the output current of the amplifier. This effect in dc transistor amplifiers is caused primarily by changes of temperature of the transistors since most of the parameters of transistors vary with the temperature.[1] Fig. 1 shows the variation of three transistor parameters, r_e, r_c and r_b with temperature for *p-n-p* junction transistors. There is however one more parameter, the "collector back current" I_{co} (which is the collector current for the emitter current equal zero) which is particularly sensitive to temperature change.[2] This parameter is related to the collector current of the transistor by the equation

$$I_c = aI_e + I_{co} \qquad (1)$$

where I_c is the collector current, I_e the emitter current, a the current amplification factor and I_{co} collector back current. Fig. 2 shows the variation of this parameter with temperature for several junction transistors. From these curves it can be seen that the current I_{co} can be expressed approximately as

---

* Decimal classification: R363.3×R282.12. Original manuscript received by the Institute, May 5, 1953; revised manuscript received October 13, 1953. This work has been supported by the U.S.A.F. Air Research and Development Command, U.S.A.F. Air Material Command, Army Signal Corps, and Navy Bureau of Ships, under Contract AF33(600)-17793.

† General Electric Co., Syracuse, N. Y.

[1] R. F. Shea, "Principles of Transistor Circuits," John Wiley & Sons, New York, N. Y., chaps. 3 and 8; 1953.

[2] E. Keonjian, "D.C. amplifier employing junction type transistors," *Elec. Eng.*, vol. 72, pp. 961–964; November, 1953.

$$I_{co} = I_s e^{0.05T} \tag{2}$$

where I_s is the current at 0 degrees C and T the temperature in degrees C. Hence

$$\frac{dI_{co}}{dT} = 0.05 I_s e^{0.05T} = 0.05 I_{co}$$

and the incremental change of this current can be written as:

$$i_{co} = 0.05 I_{co} \Delta T \tag{3}$$

where ΔT is the temperature change in degrees C. In general the temperature coefficient for I_{co} is about 5 to 10 per cent per degree C. In view of this, the temperature compensation of the dc transistor amplifiers becomes a serious problem.

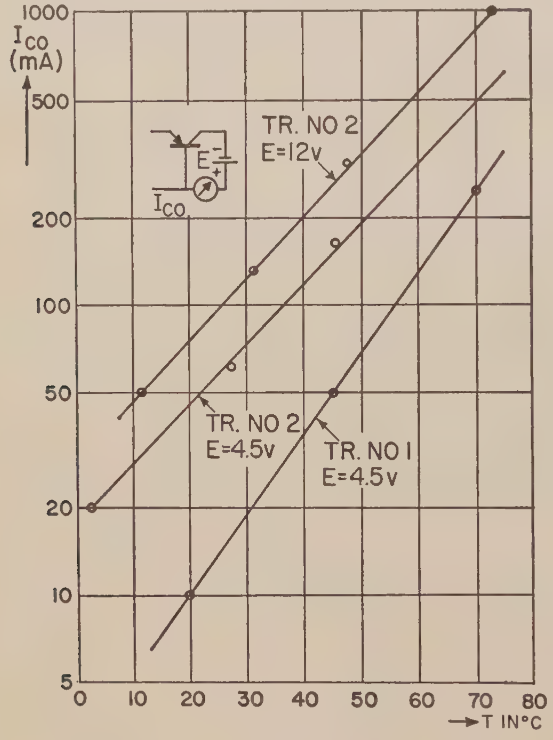


Fig. 2—Temperature characteristics of I_{co}.

Temperature Compensation of DC Amplifiers

For temperature compensation of dc amplifiers, several methods may be employed. One of these methods can be based on the proper selection of the characteristics of the various transistors employed in the dc amplifier. In order to analyze this method let us consider the effect of temperature on the collector current in a single stage transistor amplifier. The principal increment of the output current I_o of an amplifier due to the temperature change of the transistor is mainly due to a change in the collector back current I_{co} and can be expressed by the equation:

$$i_o = S i_{co} \tag{4}$$

where i_o is the increment of the output current of an amplifier, i_{co} is the increment of I_{co} and S is the stability factor of the amplifier stage as defined in the appendix. The approximate expressions for S and for current amplification factor A_i, for three basic types of transistor amplifier connections, are given in Fig. 3 (provided that $R_L \ll r_c$). In these equations R_b and R_g include all the resistances in their respective circuits, internal as well as external to the transistor: for example, for grounded-base stage

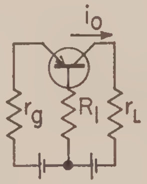
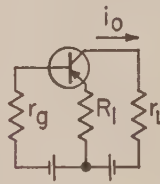
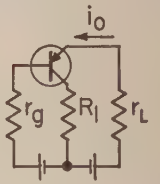
G.B.	G.E.	G.C.
		
$A_i \cong a$	$A_i \cong -\frac{a}{1-a}$	$A_i \cong \frac{1}{1-a}$
$S = \frac{R_e + R_b}{R_b(1-a) + R_e}$	$S = \frac{R_e + R_b}{R_e(1-a) + R_b}$	$S = -\frac{aR_e}{(1-a)R_e + R_b}$

Fig. 3—Three basic connections of the amplifier stage.

$$R_e = r_e + r_g$$

$$R_b = r_b + R_1.$$

In a two stage amplifier the change in output current of the first stage (i_o) is amplified by A_{i2}, the current amplification factor of the second stage. Therefore, the net change in output current of a two stage amplifier is:

$$i_L = A_{i2} S_1 i_{co1} + S_2 i_{co2} \tag{5}$$

where S_1 and i_{co2}, as well as S_2 and i_{co2} are the stability factor and the increment of current I_{co} of the first and second stages respectively.

In order to obtain temperature compensation, the current i_L must be equal to zero:

$$A_{i2} S_1 i_{co1} + S_2 i_{co2} = 0. \tag{6}$$

If both transistors are of the same type (*p-n-p* or *n-p-n*), the currents i_{co1} and i_{co2} will have also the same sign and therefore, (6) will hold only if $A_{i2}S_1$ and S_2 have opposite signs. This condition is obtained if:

1) $A_{i2} < 0;\quad S_1 > 0;\quad S_2 > 0$ (7)
2) $A_{i2} < 0;\quad S_1 < 0;\quad S_2 < 0$ (8)
3) $A_{i2} > 0;\quad S_1 > 0;\quad S_2 < 0$ (9)
4) $A_{i2} > 0;\quad S_1 < 0;\quad S_2 > 0.$ (10)

Temperature compensation may also be achieved if two transistors are of different type (one *p-n-p* and one *n-p-n*). In this case however, $A_{i2}S_1$ and S_2 must have the same sign.

If both transistors employed in the two stage amplifier are of the same type (*n-p-n* or *p-n-p*), only the following *five* connections can be used for temperature compensation of the amplifier:

1) Grounded-emitter—Grounded-emitter
2) Grounded-base—Grounded-emitter
3) Grounded-base—Grounded-collector
4) Grounded-emitter—Grounded-collector
5) Grounded-collector—Grounded-base.

The other four connections of all nine possible combinations are *not* suitable for this type of temperature compensation. These four nonsuitable combinations are as follows:

1) Grounded-base—Grounded-base
2) Grounded-emitter—Grounded-base
3) Grounded-collector—Grounded-emitter
4) Grounded-collector—Grounded-collector.

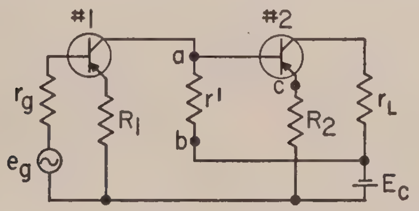


Fig. 4—Dc amplifier with two grounded-emitter stages.

Depending on the requirements (primarily in reference to the input and output resistances of the amplifier) any of the first five connections mentioned above can be used for temperature compensation. Fig. 4 illustrates one possible dc amplifier arrangement, consisting of two grounded emitter stages, employing two *p-n-p* transistors. In this arrangement, the signal developed across the load resistance r' of the first transistor is applied directly to the base of the second transistor. For proper operation of such an amplifier the dc voltage-drop across resistance r' must be sufficient to maintain the emitter of the second transistor only slightly positive with respect to the base.

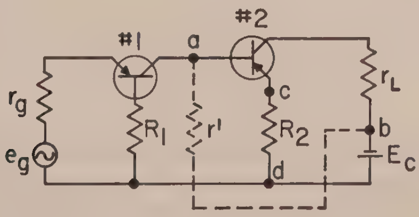


Fig. 5—Grounded-base, grounded-emitter, dc transistor amplifier.

Fig. 5 shows an amplifier, consisting of a tandem arrangement of grounded-base and grounded-emitter stages, both also employing *p-n-p* junction transistors. Here, the input resistance of the second stage serves as a load to the first stage. (Disregard r' in this diagram now. The function of r' will be mentioned later in section 5.)

In the case when an amplifier consists of two different types of transistors, one of the last four circuit arrangements, indicated above, can be used.

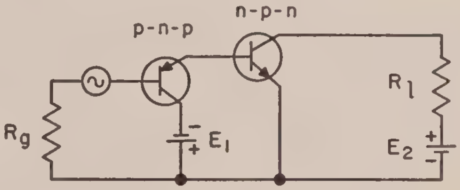


Fig. 6—Two stage dc transistor amplifier employing *p-n-p* and *n-p-n* transistors.

An arrangement of this type consisting of *p-n-p* and *n-p-n* junction transistors is shown in Fig. 6. Still other arrangements can be devised to satisfy (6), and the number of cascaded stages can be increased to provide higher gain.

Let us now consider in detail a two-stage amplifier and its temperature compensation, based on the foregoing method. Fig. 7 shows the equivalent circuit of such an amplifier in assumption that both stages are of the grounded-emitter configuration.

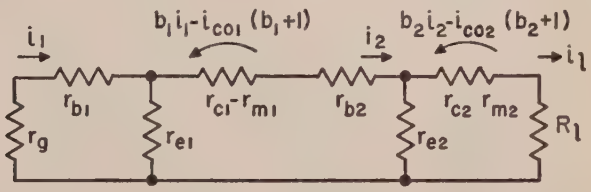


Fig. 7—Equivalent diagram of three-stage amplifier $[b=a/(1-a)]$.

The condition for the compensation given in (6) can be rewritten as:

$$A_{i2}\cdot S_1\cdot i_{co1} = i_{co2}S_2 \tag{11}$$

providing that A_{i2} has a negative sign, which is true for the grounded-emitter connection. Now if we assume

$$S_1 \cong S_2$$

then the condition for compensation will be

$$i_{co2} \cong A_{i2}i_{co1}. \tag{12}$$

From this equation it can be seen that for given A_{i2}, a pair of transistors can be so selected that the values of i_{co1} and i_{co2} will satisfy (12) for a restricted region of temperature variations. Or, for any given value of i_{co1}, A_{i2} can be selected in accordance with (12). Note, however, that the condition $S_1 = S_2$ implies that r_{g1} and r_{g2} be nearly equal. This may require an additional resistor across the input of the second stage.

In general, this method requires use of a transistor with small value of I_{co} in the first stage, and with a

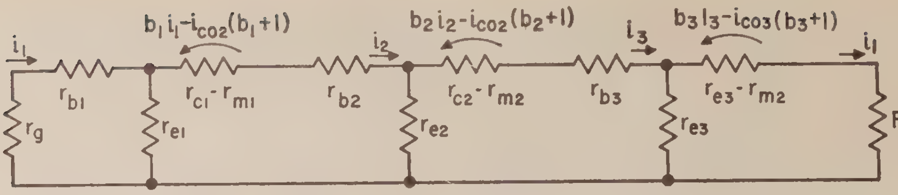


Fig. 8—Equivalent diagram of the two stage grounded-emitter amplifier [$b=a/(1-a)$].

large value of I_{co} in the second stage. A small degree of "mismatch" between the transistor characteristics can be corrected by adjusting the magnitude of negative feedback in both stages of amplifiers.

Let us consider now a three-stage grounded-emitter amplifier. Fig. 8 shows the equivalent diagram of such an amplifier. In this diagram

$$i_2 = i_{co1}S_1$$

and since A_i has a negative sign

$$i_3 = A_{i2}i_2 + i_{co2}S_2 = A_{i2}i_{co1}S_1 + i_{co2}S_2$$

$$i_L = A_{i3}i_3 + i_{co3}S_3 = A_{13}A_{12}i_{co1}S_1 + A_{i3}i_{co2}S_2 + i_{co3}S_3.$$

The amplifier will be temperature compensated if

$$A_{13}A_{12}i_{co1}S_1 + i_{co3}S_3 = -A_{i3}i_{co2}S_2. \qquad (13)$$

This condition is shown in the diagram of Fig. 9, which presents all the currents of interest in the amplifier, within their relative directions at the outputs of each stage.

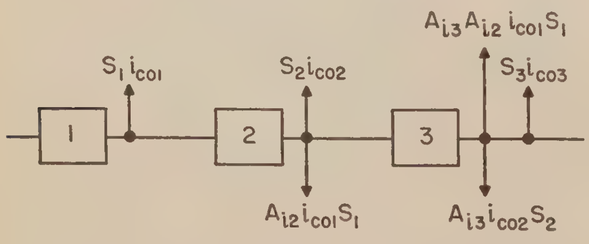


Fig. 9—Relative direction of the currents in the three-stage amplifier.

If the stability factor S of each stage is selected so that

$$S_1 \cong S_2 \cong S_3$$

the condition for compensation will be

$$A_{13}A_{12}i_{co1} + i_{co3} \cong -A_{i3}i_{co2}. \qquad (14)$$

This simplified version, normalized in terms of S, is shown in Fig. 10. If we ignore i_{co3} in (14) as compared to $A_{i3}A_{12}i_{co1}$, then

$$i_{co2} \cong -A_{i2}i_{co1}$$

which indicates again that the transistor with smallest I_{co} should be placed in the first stage. The same note as above concerning equality of S also applies here.

From Fig. 10 it is apparent that if

$$i_{co2} < (A_{i2})i_{co1}$$

the output of the amplifier is not compensated. The same is true if

$$i_{co2} = (A_{i2})i_{co1},$$

i.e., if only the second stage is compensated. Therefore, the condition (13) must be read only as

$$i_{co2} > (A_{i2})i_{co1}, \qquad (15)$$

i.e., we can achieve compensation at the output of the amplifier *only if the preceding (second) stage is overcompensated.*

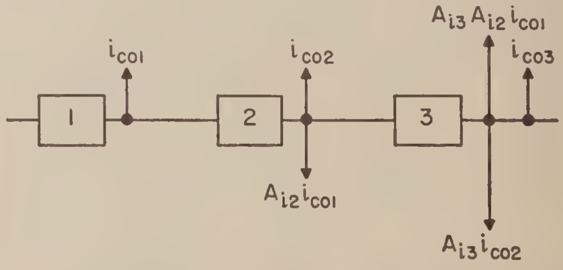


Fig. 10—Simplified version of diagram of Fig. 9, when $S_1 \approx S_2 \approx S_3$.

The "current direction" method of stabilization described above, which was based on linear operation of the amplifier, and on the assumption that other parameters of the transistors are not affected by temperature, is a very simple one. However, it is not entirely practical, since it requires transistors of the particular characteristics in each stage, and compensation can be achieved for very restricted regions of temperature variation.

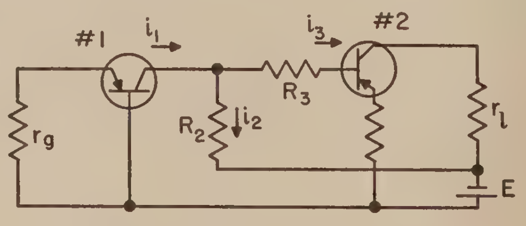


Fig. 11—Circuit arrangement for temperature stabilization of a dc amplifier.

SOME CIRCUIT ARRANGEMENTS

It is possible to a degree to achieve a temperature compensation by some simple circuit arrangements.

Fig. 11 shows one such arrangement where a resistance R_3 is placed in series with the base of the transistor no. 2. In this circuit the current increment i_1 due to the change of temperature of transistor no. 1, is divided into currents i_2 and i_3 flowing through resistances R_2 and R_3 respectively.

Due to current i_3, a current increment will appear (with phase reversed on the collector side of transistor no. 2). The ratio between R_2 and R_3 may be so chosen that this current increment will compensate the current increment which is due to the change of temperature of transistor no. 2, resulting in the net increment i_L becoming zero.

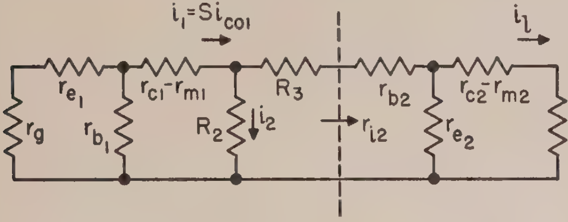


Fig. 12—The equivalent diagram of the circuit of Fig. 11.

Fig. 12 shows an equivalent diagram of this arrangement. In this diagram, the current i_3 is equal:

$$i_3 = S_1 i_{co1} \frac{R_2}{R' + R_2}$$

where

$$R' = R_3 + r_{i2},$$

r_{i2} is the input resistance of the second stage and S is the "stability factor" as defined previously.

The current i_3 will appear amplified in the output of the last transistor as current i_L':

$$i_L' = S_1 i_{co1} \frac{R_2}{R' + R_2} \cdot b_2 \tag{16}$$

where

$$b_2 = \frac{a}{1 - a} = A_{i2}.$$

The current increment in i_L due to i_{co2} is

$$i_L'' = i_{co2}(b + 1). \tag{17}$$

For temperature compensation

$$i_L' = i_L''$$

or

$$i_{co2}(b + 1) - S_1 i_{co1} \frac{R_2}{R' + R_2} \cdot b_2. \tag{18}$$

Now, if $b_2 \gg 1$, then the condition for temperature compensation will be

$$i_{co2} = i_{co1} S_1 \frac{R_2}{R' + R_2} \cdot \tag{19}$$

The disadvantage of this method is the considerable loss of the gain due to resistance R_3.

Fig. 13 shows another circuit arrangement (excluding batteries) which can be used for temperature compensation. Here, resistance R_3 is placed in series with the load resistance r_L. The current increment Si_{co1} due to the change of temperature of transistor no. 1, is divided into currents i_1 and $Si_{co1} - i_1$ flowing through the base of the transistor #2 and resistance R_1 respectively.

The current i_1 is equal to

$$i_1 = S_1 i_{co1} \frac{R_2 + R_3}{R_2 + R_3 + r_{i2}}$$

where r_{i2} is the input resistance of the second stage.

The current i will appear amplified in the output of the second stage as current i_L

$$\begin{aligned} i_L &= - b_2 i_1 + i_{co2}(b_2 + 1) \\ &= - S_1 i_{co1} b_2 R + i_{co2}(b_2 + 1) \end{aligned}$$

where

$$R = \frac{R_2 + R_3}{R_2 + R_3 + r_{i2}} \cdot$$

The current through the emitter branch of the second transistor, i_2, is:

$$\begin{aligned} i_2 = i_1 + i_L &= S_1 i_{co1} R - S_1 i_{co1} b_2 R + i_{co2}(b_2 + 1) \\ &= S_1 i_{co1} R(1 - b_2) + i_{co2}(B_2 + 1). \end{aligned}$$

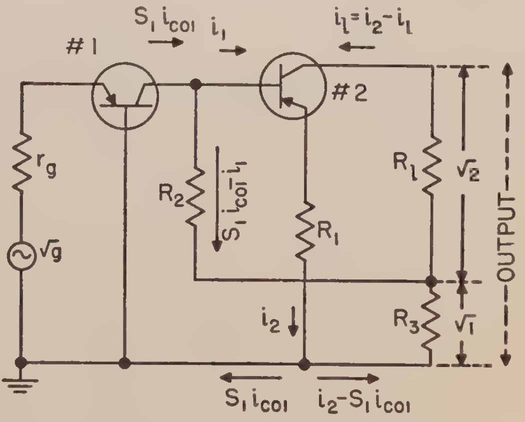


Fig. 13—Circuit diagram of a two-stage dc amplifier (batteries are not shown).

For temperature compensation, the voltage drop V_2 across R_L must be equal and opposite in sign to the voltage drop V_1 across R_3. Thus:

$$V_1 + V_2 = R_3(i_2 - S_1 i_{co1}) + R_L i_L = 0 \tag{20}$$

or

$$\begin{aligned} &R_3(i_L + i_1 - S_1 i_{co1}) + R_L i_L \\ &\quad = (R_L + R_3) i_L + R_3(i_1 - S_1 i_{co1}) = 0. \end{aligned}$$

Substituting the corresponding values

$$\begin{aligned} &(R_L + R_3)\left[(- b_2 S_1 i_{co1} R + i_{co2}(b_2 + 1)\right] \\ &\quad + R_3\left[S_1 i_{co1} R - S_1 i_{co1}\right] = 0. \end{aligned}$$

If $b_2 \gg 1$

$$- b_2(R_L + R_3)\left[S_1 i_{co1} R - i_{co2}\right] + R_3 S i_{co1}(R - 1) = 0$$

and the condition for the temperature compensation will be:

$$R_3S_1i_{co1}(R-1) = b_2(R_L+R_3)[S_1i_{co1}R - i_{co2}]. \quad (21)$$

Depending on the characteristics of the transistors, the values of resistances R_1, R_2 and R_3, as well as the value of S_1, may be chosen such that the output voltage of the amplifier will not be affected by the changes of the ambient temperature.

Equation (21) can be rewritten as

$$(R-1)i_{co1} = \frac{b_2}{S_1}\left(\frac{R_L}{R_3}+1\right)[Si_{co1}R - i_{co2}]$$

$$1 - R = \frac{b_2}{S_1}\left(\frac{R_L}{R_3}+1\right)\left[\frac{i_{co2}}{i_{co1}} - S_1R\right]. \quad (22)$$

From (22) it can be seen that one of the conditions for the compensation is

$$\frac{i_{co2}}{i_{co1}} > S_1R. \quad (23)$$

Now, if (22) will be rewritten in the following form

$$\frac{1-R}{1+\dfrac{R_L}{R_3}} = \frac{b_2}{S_1}\left[\frac{i_{co2}}{i_{co1}} - S_1R\right] \quad (24)$$

it will indicate another condition which must be also satisfied in order to achieve the temperature compensation. This condition is:

$$\frac{b_2}{S_1}\left[\frac{i_{co2}}{i_{co1}} - S_1R\right] < 1. \quad (25)$$

If we assume that $b_2/S_1 \gg 1$, then

$$\left[\frac{i_{co2}}{i_{co1}} - S_1R\right] \ll 1$$

or

$$\frac{i_{co2}}{i_{co1}} \cong S_1R. \quad (26)$$

In practical applications the foregoing two circuit arrangements require a considerable effort for adjustment of all the components of the circuits in order to achieve a proper operation. Therefore, even this method cannot be considered entirely practical.

TEMPERATURE COMPENSATION WITH NONLINEAR RESISTANCE

The temperature compensation of the dc transistor amplifiers can be greatly simplified and improved if one of the circuit components of the amplifier (resistor r' in Figs. 4 or 5) is replaced by a temperature-sensitive element such as junction diode, thermistor or similar type devices. By proper choice of the characteristic of this element, it will automatically adjust the bias of the second transistor stage so that the dc collector current of this transistor remains constant as the ambient temperature varies.

Since the temperature affects almost all the parameters of transistors, as well as all external "permanent" resistors employed in the amplifier circuit, it would be very difficult to take all the factors which are due to temperature into account in order to calculate the proper characteristic of the compensating temperature-sensitive resistance mentioned above. Therefore, for simplicity (and greater accuracy also) the characteristics may be determined experimentally for any pair of transistors in the amplifier circuit, as follows.

In the circuit of Fig. 4, the resistance r' is replaced by a variable resistance. Then, for any given ambient temperature, the value of this resistance is adjusted so that the output current of the amplifier, I_o, remains constant. The plot of these values of resistance against temperature will then represent the desired temperature characteristic of the temperature-sensitive resistance.

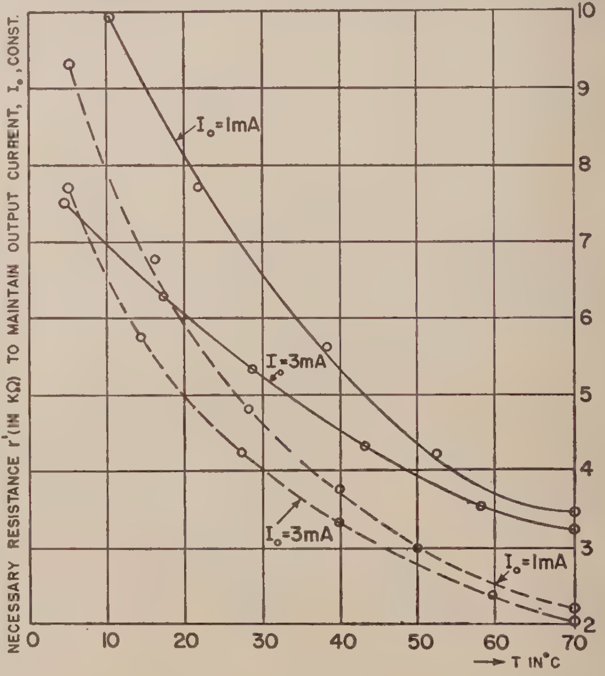


Fig. 14—Temperature characteristic of resistance r'.

This means that a resistance having this temperature characteristic, being substituted for r', will maintain the output current I_o constant as the ambient temperature is changed. Fig. 14 shows such a characteristic obtained experimentally for the two-stage amplifier shown in Fig. 5. The variable resistance r' was placed between the points a–b as shown. The parameters of the p-n-p junction transistors employed in the amplifier are shown in Table I.

TABLE I

	α	r_c	r_b	r_e	I_{co}
Transistor 1	0.96	1 meg.	600 Ω	20 Ω	6 μA
Transistor 2	0.94	140 KΩ	340 Ω	32 Ω	40 μA

The first set of curves (solid lines) were obtained with transistor 1 used in the first stage and transistor 2 in the second stage. The second set of curves (dotted lines) represent the case where the transistors are interchanged. In each case, the characteristics were taken for two constant values of output current I_0, 1 ma and 3 ma.

After the curves of the compensating resistance have been obtained, a suitable temperature-sensitive element must be found to replace resistor r' in Figs. 4 or 5. A "suitable" resistance should not only have the required temperature characteristics but also the same thermal time-constant, as the transistors used in the amplifier. If the last requirement is not satisfied, the chosen resistor will not respond to the temperature changes simultaneously with the transistor and therefore the amplifier will not be truly compensated.

TEMPERATURE-SENSITIVE ELEMENTS

In the realization of the proposed method of temperature compensation, a number of temperature-sensitive elements may be used. Among these elements are: (a) special types of ceramic resistors, (b) thermistors, (c) germanium diodes.

Ceramic Resistors

These resistors are made of compositions with marked negative temperature coefficients (approximately 1.0 per cent to 2.0 per cent per degree C. at 25 degrees C.). The temperature coefficient of these resistances is:

$$a = \frac{B}{T^2} \tag{27}$$

where B is a constant given below and T the absolute temperature in degrees Kelvin. It has been found empirically that these resistors obey an equation of the form:

$$R = R_o e^{B(1/T - 1/T_o)} \tag{28}$$

to an accuracy equal to or better than the measured temperature resistance curves. In this equation, T_o is the reference temperature in degrees Kelvin (for 25 degrees C., $I/T_o = 0.003356$), R = the resistance at temperature T, R_o = the resistance at reference temperature, T = temperature of the resistor in degrees Kelvin and B = the temperature constant.

A more convenient form of this equation for computation is:

$$\log \frac{R}{R_o} = 0.4343B\left(\frac{1}{T} - \frac{1}{T_o}\right). \tag{29}$$

The value of the constant B varies with the resistivity of the composition and can be obtained from the curves supplied by the manufacturer. Two samples of resistors (Glober Division, Carborundum Co.) which were tested had the following values of B:

#763F $R_o = 6{,}000 \pm 10\%$; $B = 2{,}000 \pm 10\%$
#549H $R_o = 6{,}000 \pm 20\%$; $B = 3{,}100 \pm 10\%$.

Thermistors

The word "thermistor" actually applies to any resistor which changes its resistance with temperature. Usage, however, has limited the connotation to resistors with negative temperature coefficients. Thus, the thermistor is a temperature-sensitive resistor consisting of a sintered combination of ceramic materials and various metallic oxides (generally known as semiconductors). The negative temperature coefficient of thermistors is of the order of 2.5 per cent per degree C. at 20 degrees C.

Germanium Diodes

If the germanium diode is properly biased, so that the negative dc potential is applied to the whisker and positive potential to the base, the corresponding back resistance of the diode will strongly depend on the temperature of the diode and also will vary with applied dc voltage. These properties of the diode make it an excellent temperature-sensitive device with temperature coefficient of the order of 5 per cent per degree C. at 25 degrees C.

Fig. 15 shows the characteristics of two G.E. junction diodes taken at a dc voltage of 4.5 v.

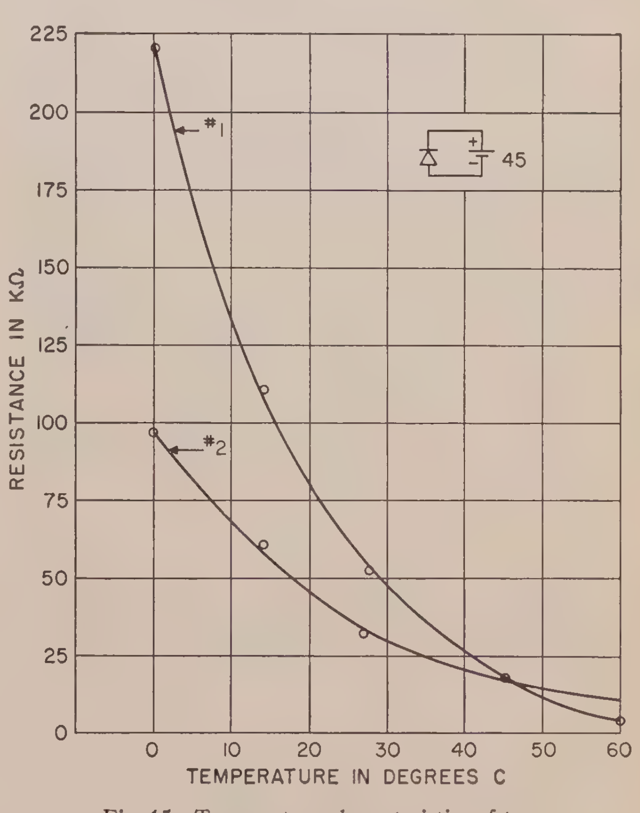


Fig. 15—Temperature characteristics of two junction diodes at 4.5 v.

Fig. 16 shows a family of characteristics "diode resistance versus applied dc voltage" for another G.E. diode, measured at three different temperatures. These curves illustrate the great possibilities which are offered by a diode as a compensating element.

OPERATING CHARACTERISTICS OF A TEMPERATURE-COMPENSATED AMPLIFIER

Despite the fact that all the different types of temperature-sensitive resistors mentioned offer a great variety of characteristics, it is impossible to select a particular one which would have exactly the same shape as required for complete-temperature compensation of an amplifier. For a practical application, the temperature-sensitive element must be used in the amplifier circuit in conjunction with a special "shaping" network of series and parallel resistances, which will change the characteristic of the temperature-sensitive resistance to that required for compensation.

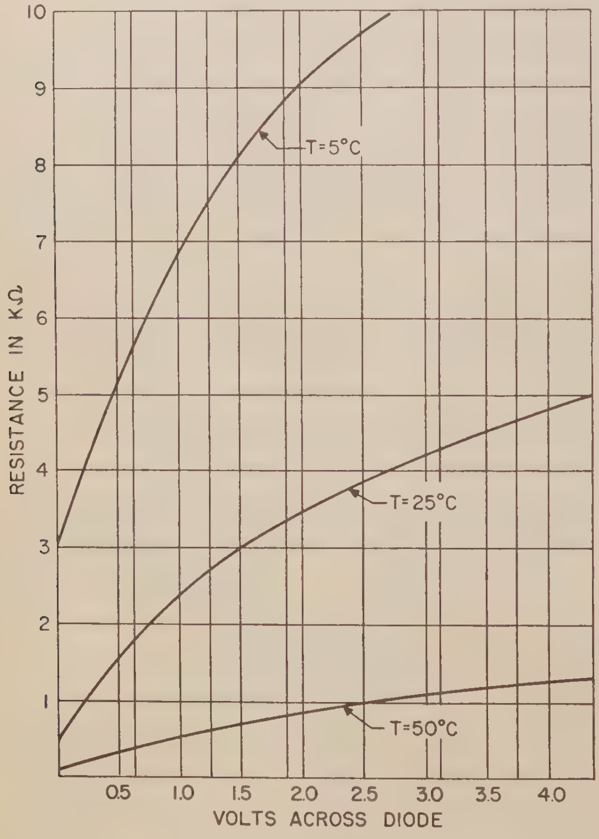


Fig. 16—Diode back resistance vs voltage.

In Fig. 17 a circuit diagram of the temperature-compensated dc amplifier is shown. This arrangement utilizes the previously mentioned idea of temperature compensation by means of nonlinear elements (diode D).

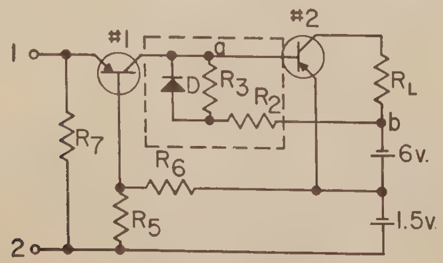


Fig. 17—Temperature-compensated amplifier employing a junction diode as a compensating element.

The complete compensating network including the characteristic shaping resistors is indicated in the circuit diagram by the dotted line.

The primary reason for the choice of the diode in preference to other types of nonlinear resistors, was that the time-constant of these devices was similar to that of the transistors in the amplifier.

When a temperature-sensitive resistor is used in conjunction with a shaping network, it must have a greater rate of change of resistance with temperature than is required by the combination. From this standpoint, diodes are preferable, since their temperature coefficients are relatively high (5 per cent per degree C. at 25 degrees C.). Fig. 18 shows the temperature characteristics of an experimental amplifier utilizing the circuit of Fig. 17. Curve no. 1 shows the behavior of the compensated amplifier while curve no. 2 represents the noncompensated amplifier (with diode D removed and values of the resistors changed to maintain the output current, I_o, at its original value). Note the extreme change of output current, I_o, with temperature for the non-compensated amplifier: A temperature variation of less than 20 degrees C. is enough to produce 100 per cent change in output current.

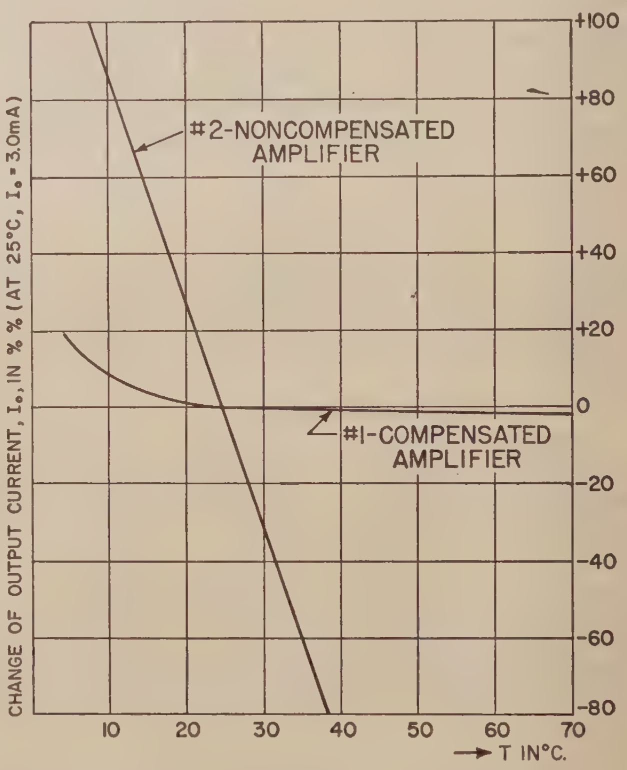


Fig. 18—Temperature characteristics of compensated amplifier.

The curve representing the compensated amplifier is still far from ideal, but with the addition of one more resistance between points *a* and *b*, and by readjusting the shaping networks, the temperature characteristic of the amplifier may be further improved.

Fig. 19 shows the temperature characteristics of an amplifier when compensating network consisted of three shaping resistors. As it can be seen, the temperature compensating in this case is more satisfactory.

From Fig. 14 can be seen that the shape of the characteristic required for the compensating network depends greatly upon the initial value of the output current, I_o.

The smaller I_o becomes, the steeper the required compensating characteristic $r' = f(T°)$ and vice-versa. Therefore, if the temperature characteristic of the amplifier shows some under or over-compensation, this may be improved by a small resetting of the initial value of current I_o.

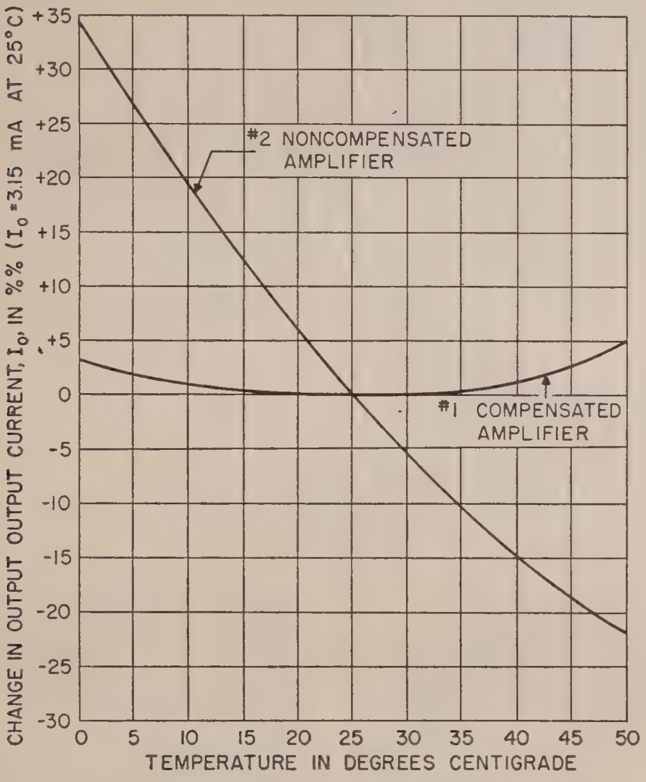


Fig. 19—Temperature characteristics of amplifier with three shaping resistors.

Table II contains general data on the circuit elements for the amplifiers illustrated in Fig. 17. The input resistance of the amplifier (measured between terminals 1 and 2) is of the order of 50 ohms.

TABLE II

Trans. 1 & 2	Diode D	R_2	R_3	R_4	R_6	R_7	R_L	Output Current I_o	Power Gain G	Total Power Consumption
See Table I	G.E. Junc. Diode	2,950 ohms	9,350 ohms	80 ohms	620 ohms	100 ohms	100 ohms	3ma	20db	24mw

Practical performance of the amplifiers is also affected by the stability of the power supply. Since dc transistor amplifiers require a very small amount of power, batteries may be an adequate source of power. However, it is still necessary to consider the temperature stability of the batteries. The temperature coefficient of a typical dry cell battery is +0.0016 volt per degree per cell in the range of 15 to 20 degrees C. Thus, a 12 v battery will have a temperature coefficient of the order of +13 mv per degree C. To minimize this effect, it is desirable to operate the dc amplifier from a low voltage power source.

Thermal effects in transistors play a great part in dc amplifiers.

Fig. 20 shows a typical drift curve for a dc transistor amplifier, illustrated in Fig. 17. As may be seen, the final value (3.08 ma) is reached only after one hour, which must be regarded as a minimum "warmup" time for described dc transistor amplifier.

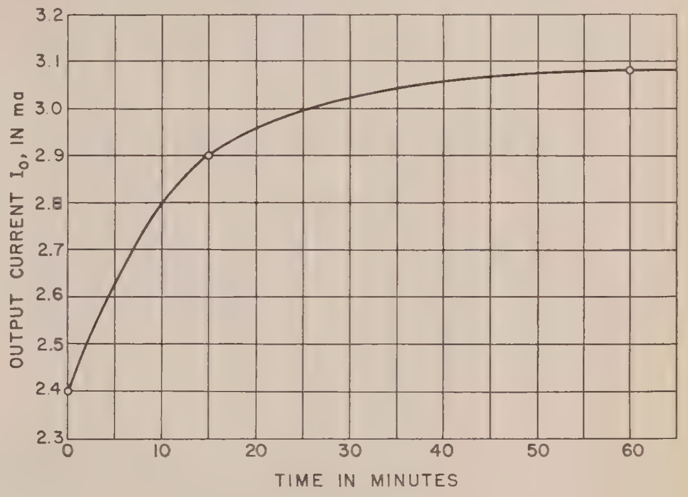


Fig. 20—Transition curve of output current I_o.

Fig. 21 shows "on" and "off" effects on the output current for three different durations of the "off" period (one second, one minute and five minutes). As may be seen, the amplifier current reaches its final value in a time which depends upon the duration of its "off" period. Thus only ten seconds is required to reach the final value of the output current when the off time is one second; ten minutes is required for one minute "off" and an hour is required if the amplifier is "off" five minutes or more.

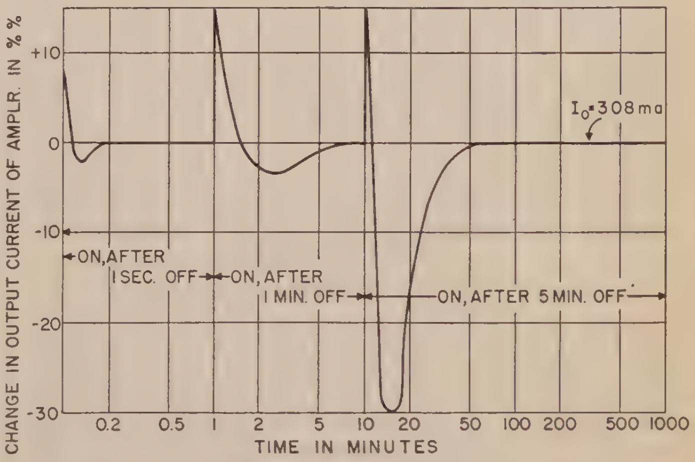


Fig. 21—"On" and "Off" response of the amplifier.

Figs. 22 and 23 show the frequency and amplitude characteristics respectively, of the amplifier illustrated in Fig. 17. The latter curve gives an idea of the dynamic range of the amplifier (ratio between maximum and minimum undistorted outputs). In this case the dynamic range is over 60 db. The upper limit of the dynamic range is limited primarily by the characteristics of the first transistor, since the collector voltage of the first transistor is relatively low. The lower limit of the dynamic range is determined by the noise level of the amplifier. According to the measurements, the noise figure of the above mentioned amplifier was very high (50 db). However, it must be noted that the transistors used in this amplifier were particularly bad as far as noise figure is concerned and therefore the noise value of 50 db cannot be considered as typical for the dc amplifier. By proper choice of the transistors, their collector voltages and the coupling resistances between the stages, the noise figure of the dc amplifier can be reduced considerably. This means that proper choice of transistors and their operating points could extend the lower level of the dynamic range by an additional 5 to 10 db. This will permit the amplifier to amplify signals as low as 1–2 μV. In view of all the difficulties which have been encountered in dc transistor amplifiers, a dynamic range of that order (70 db) must be considered as being exceptionally good.

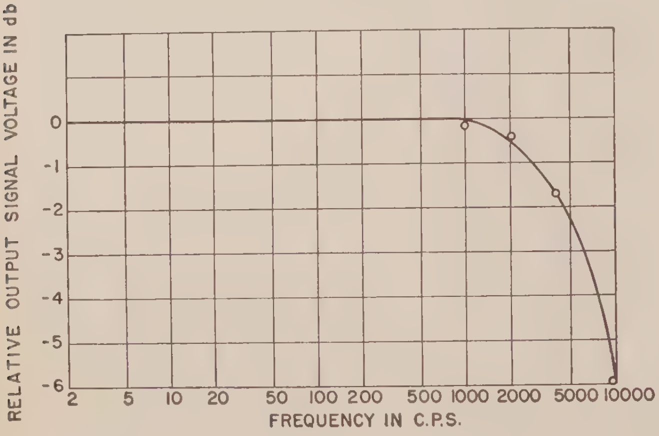


Fig. 22—Frequency characteristic of the amplifier.

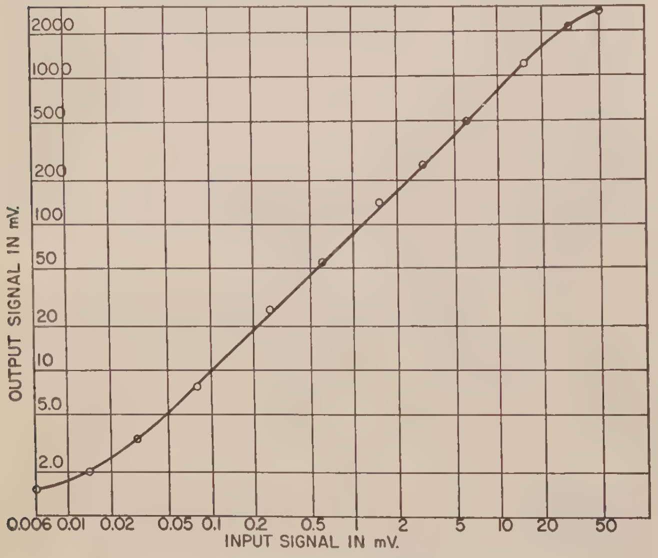


Fig. 23—Amplitude characteristic of the amplifier.

During the 106-hour test, the drift due self-heating in the transistors (at constant ambient temperature) was negligibly small (0.1 per cent), remaining almost within the limits of noise fluctuation in the output current of the amplifier. The maximum drift due to change in the ambient temperature, from 0 degrees C. to 50 degrees C., for a well-balanced circuit was only slightly above 5 per cent.

The performance of a dc transistor amplifier is also affected by the temperature coefficient of the resistors used in the circuit. Fig. 24 shows the temperature characteristics of a typical fixed-composition resistor and wire-wound resistors. As may be seen, the fixed composition resistors of that type have comparatively negligible temperature coefficients within the temperature range of 20 degrees C. to 60 degrees C. However, wire-wound resistors are preferable because composition resistors generally produced noise, which, like transistor noise, is most serious at low frequencies.

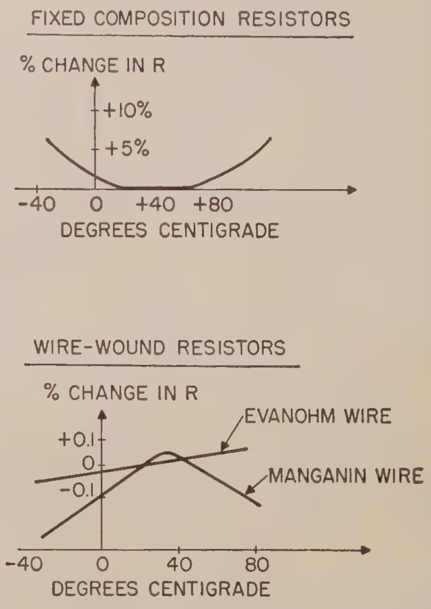


Fig. 24—Temperature characteristics of different type resistors

There are still a number of principal problems which are involved in the dc transistor amplifier. Among these problems, which still are awaiting their solution, this is the study of the affect of the transistor parameters spread (particularly within the units of the same type) upon the performance of the compensated amplifier and the determination of the permissible amount of this spread which is required for the complete reproducibility of the temperature compensation.

APPENDIX

Derivation of stability factor S (see Fig. 25)

$$R_e = r_e + r_g$$

$$R_b = r_b + R_1$$

$$i_e + i_b = i_c = ai_e + i_{co}$$

$$R_e i_e = R_b i_b$$

$$i_e\left(\frac{R_e}{R_b}\right) + i_e = ai_e + i_{co}$$

$$i_e\left(\frac{R_e}{R_b}\right) + i_e(1-a) = i_{co} \qquad i_o = \frac{i_{co}}{\dfrac{R_e}{R_b} + (1-a)}$$

$$i_c = ai_e + i_{co} = i_{co}\left[1 + \frac{a}{\dfrac{R_e}{R_b} + (1-a)}\right]$$

$$= i_{co}\left[\frac{R_e + R_b(1-a) + aR_b}{R_e + R_b(1-a)}\right]$$

$$= i_{co}\left[\frac{R_b + R_e}{R_e + R_b(1-a)}\right] = i_{co}S$$

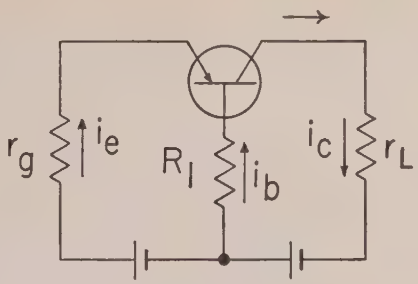


Fig. 25—Grounded-base amplifier.

ACKNOWLEDGEMENT

The many suggestions received from J. S. Schaffner and R. F. Shea during the course of this work, and the assistance of the staff of the Electronics Laboratory, General Electric Company, are gratefully acknowledged.

Design of RC Wide-Band 90-Degree Phase-Difference Network[*]

DONALD K. WEAVER, Jr.[†], ASSOCIATE MEMBER, IRE

Summary—**This paper presents a design procedure for the practical design of RC wide-band 90-degree phase-difference networks. The important part of the paper is the design procedure given in "cookbook" fashion with a numerical example to clarify it. This procedure consists of many steps, each step being a relatively simple one. This should make it a useful design tool for people without much background in network theory. A brief theoretical introduction is presented but this is far too sketchy to be of much use in understanding just what is behind the design procedure. Some practical hints on construction and alignment are given.**

INTRODUCTION

THE PHASE ROTATION method of generating a single sideband amplitude-modulated signal requires the use of 90-degree phase-difference networks covering the audio frequency band. The purpose here is to present a design procedure for obtaining these networks and to discuss some of the practical matters which arise in their construction and alignment.

The important part is the design procedure with the numerical example. Except somewhat briefly as follows, a complete theoretical background, necessary to understand each design step, is beyond the scope of this paper, since it has been covered mostly in one form or another in the literature. (See Bibliography.)

Two all-pass networks, connected as shown in Fig. 1, can be designed to have the phase difference between their output voltages approximate a constant over a band of frequencies shown in Fig. 2. The Tschebyscheff type of equal ripple approximation is used, and only the special case of approximating a 90-degree phase difference will be covered. The two networks of Fig. 1 can be further restricted so that they can be constructed with resistances and capacitances only. This requires that the poles of the response functions shall be real.

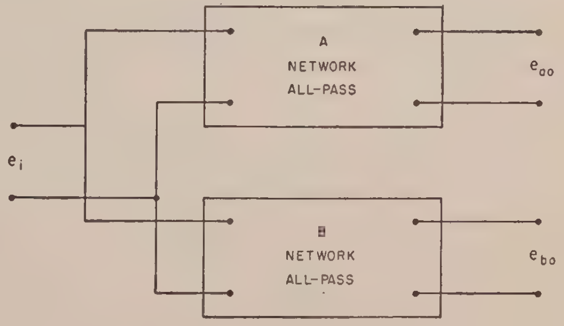


Fig. 1—Phase-difference networks.

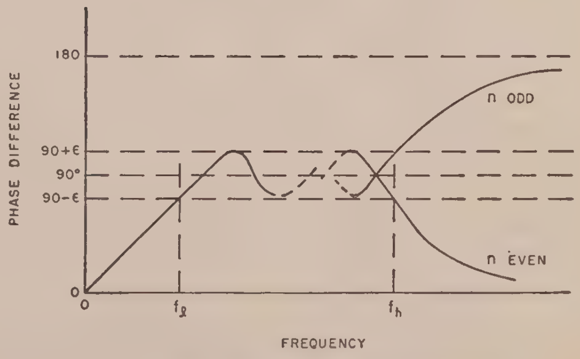


Fig. 2—Equal ripple phase-difference function.

The general response functions of the two all-pass networks having the RC restriction are given by (1) and (2).

---

[*] Decimal classification: R143. Original manuscript received by the Institute, February 12, 1953; revised manuscript received, October 7, 1953. The work of this paper was supported in part by Coles Signal Laboratory under Signal Corps Contract No. W-36-039-sc-38199 and Air Research and Development Command, Rome Air Development Center, under Air Force Contract No. AF 28(099)-153.

[†] Stanford Research Institute, Stanford, Calif.

$$f_a(P) = \frac{e_{a0}}{e_i} = K\frac{(P-\sigma_{a1})(P-\sigma_{a2})(\quad)(\quad)}{(P+\sigma_{a1})(P+\sigma_{a2})(\quad)(\quad)}. \qquad (1)$$

$$f_b(P) = \frac{e_{b0}}{e_i} = K\frac{(P-\sigma_{b1})(P-\sigma_{b2})(\quad)(\quad)}{(P+\sigma_{b1})(P+\sigma_{b2})(\quad)(\quad)}. \qquad (2)$$

The values of σ are real and positive.

The problem of design divides into two main parts. First, the pole-zero pairs or values of σ must be determined so that the difference between the phase shift of the two networks approximates 90 degrees over the required relative bandwidth. This determines the response functions of the two networks. The second part of the problem is to find two RC networks that realize these response functions.

RESPONSE FUNCTIONS

The phase-difference function is obtained by taking the ratio e_{a0}/e_{b0}. The poles of the response function must be *negative real* numbers, but the poles of the phase-difference function can be either positive or negative. However, they cannot be zero or infinite.

Locating the pole-zero pairs of the phase-difference function on the real axis of the complex frequency plane (p-plane, $p=\sigma+j\omega$) is greatly simplified by the use of the conformal transformation (3).

$$p = \text{tn}\,(z, k). \qquad (3)$$

This is the elliptic tangent transformation and maps the p-plane in a doubly-periodic fashion. The mapping of the ω axis branches twice at right angles in such a way that a band of the ω axis maps parallel to the mapping of the σ axis.

To obtain 90-degree phase difference the poles and zeros are alternated with equal spacing along the mapping of the σ axis. The additional restrictions are that they obey the periodicity rule of the mapping function and the rules of RC all-pass functions. This completely determines pole-zero locations once numbers of poles and zeros in the phase-difference functions are known.

The bandwidth ratio f_h/f_l determines the modulus k of the elliptic tangent. Once this is fixed the maxima of the error, ϵ, is determined by the number of pole-zero pairs, n, in the phase-difference functions.

After these pairs are located in the z-plane they are found in the p-plane using (3). These values are then substituted into (1) and (2), putting the negtaive poles into $f_a(p)$ and the positive poles as zeros in $f_b(p)$. This is a very brief explanation of the theory behind steps 1 through 5 of the design procedure. It is not expected that the design procedure would easily follow from the above. However, the design steps will give the answer and they can be followed in "cookbook" fashion without any need for an understanding of the underlying theory.

NETWORK REALIZATION

The realization problem does not have a unique result as there are many different network configurations which will have the same response function. A convenient configuration to use is the half-lattice driven by a balanced transformer shown in Fig. 3. The response function of this configuration is given by (4).

$$f(p) = \frac{e_0}{e_i} = \frac{1-\dfrac{Z_x}{Z_y}}{1+\dfrac{Z_x}{Z_y}}. \qquad (4)$$

Solving this for Z_x/Z_y we obtain

$$\frac{Z_x}{Z_y} = \frac{1-f(p)}{1+f(p)}. \qquad (5)$$

Values of p that make $1-f(p)=0$ must be either zeros of Z_x or poles of Z_y. Similarly, values of p satisfying $1+f(p)=0$ must be either poles of Z_x or zeros of Z_y.

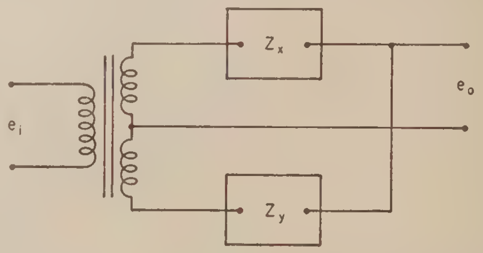


Fig. 3—All-pass half-lattice network.

The two impedance functions Z_x and Z_y are to contain only resistance and capacitance and therefore must have all their poles and zeros on the negative σ axis of the p-plane. This condition will be satisfied if the values of K_a and K_b in (1) and (2) are small enough. This implies that the RC configuration will result in a certain minimum attenuation corresponding to the maximum values of K which produces all real poles and zeros of (5).

The poles and zeros of (5) must be divided between Z_x and Z_y so that both are physically realizable RC impedance functions. Then each impedance can be realized in the canonical form shown in Fig. 4. There are usually several alternative ways the poles and zeros of (5) can be divided between the two impedances. These result in different yet equivalent networks.

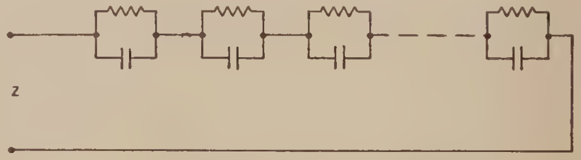


Fig. 4—Canonical form of RC impedance.

The poles and zeros of an impedance function determine the impedance except for a constant multiplier which adjusts the impedance level of the network. The absolute values of the constants are determined from practical considerations such as the range of element values available. However, the relation between the impedance levels for Z_x and Z_y is important and is given by:

$$\frac{K_x}{K_y} = \frac{1-K}{1+K} \qquad (6)$$

where K is the constant of the response functions in (1) and in (2).

It is convenient to have the network terminated in a load. These networks commonly work into the grid of a vacuum tube so it would be ideal if the network could be terminated in a resistance to be used as a grid leak and a capacitance to account for the input capacitance of the tube. The well-known equivalent circuits of Fig. 5 form the basis for obtaining a load impedance. The load impedance, Z_1, is removed from Z_x and Z_y leaving Z_{x1} and Z_{y1} in the lattice. These are then realized in the canonical form of Fig. 4. The resulting networks have the schematic diagram of Fig. 6.

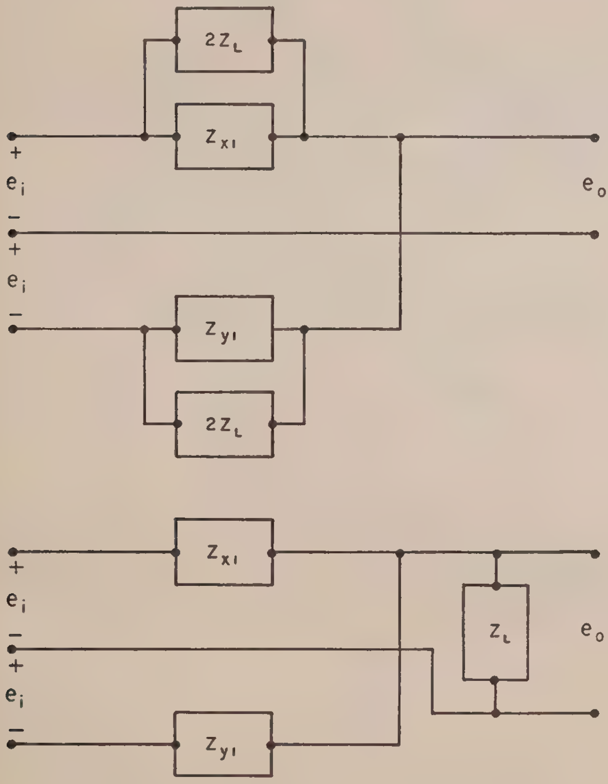


Fig. 5—Equivalent circuits.

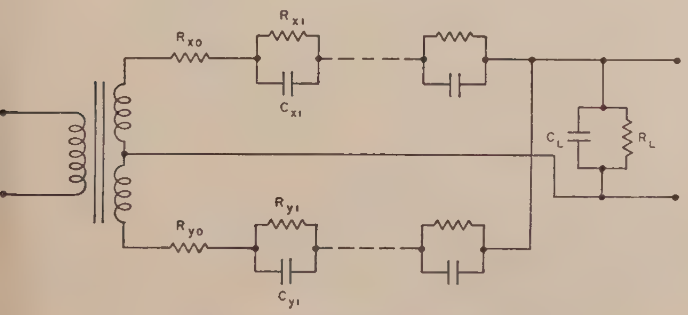


Fig. 6—Schematic diagram of all-pass network.

Design Procedure

Requirements

Lower band edges, f_l cps; upper band edges, f_h cps; tolerance, ϵ degrees.

1. From bandwidth-ripple curves (Fig. 7) determine the network complexity n. Leave some safety factor for alignment tolerance.

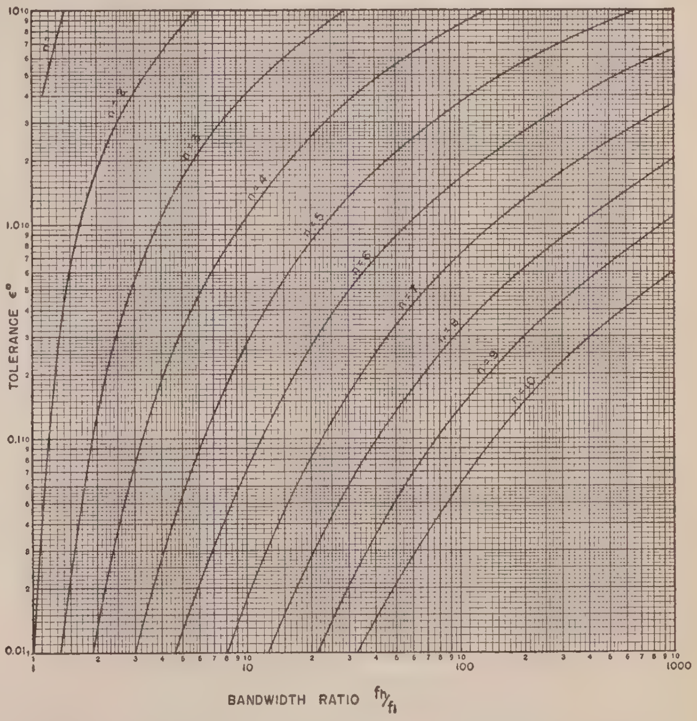


Fig. 7—Bandwidth-ripple curves.

2. Compute q:

(a) $k' = \dfrac{f_l}{f_h}$

(b) $k = \sqrt{1 - k'^2}$

(c) $l = \dfrac{1}{2}\,\dfrac{1-\sqrt{k}}{1+\sqrt{k}}$

(d) $q' = l + 2l^5 + 15l^9 + \cdots$

(e) $q = e^{\pi^2/\ln q'}$.

3. Compute the sets of angles ϕ_r and ϕ_r' for the A and B networks:

(a) $\phi_{ar} = \dfrac{90}{2n}(4r - 3),\ r = 1, 2, \cdots, \dfrac{n}{2}$

or

$\dfrac{n+1}{2}$ [A network]

(b $\phi_{br} = \dfrac{90}{2n}(4r - 1),\ r = 1, 2, \cdots, \dfrac{n-1}{2}$

or

$\dfrac{n}{2}$ [B network]

(c) $\phi_{ar}' = \tan^{-1}\dfrac{(q^2 - q^6)\sin 4\phi_{ar}}{1 + (q^2 + q^6)\cos 4\phi_{ar}}$ [A network]

$$\text{(d)}\quad \phi_{br}' = \tan^{-1}\frac{(q^2 - q^6)\sin 4\phi_{br}}{1 + (q^2 + q^6)\cos 4\phi_{br}} \quad \text{[B network]}.$$

4. Determine the sets of σ_{ar} and σ_{br}:

$$\text{(a)}\quad \sigma_{ar} = \frac{1}{\sqrt{k'}}\tan(\phi_{ar} - \phi_{ar}')$$

$$\text{(b)}\quad \sigma_{br} = \frac{1}{\sqrt{k'}}\tan(\phi_{br} - \phi_{br}').$$

5. The response functions of the two networks are given by:

(a) A network—

$$f_a(p) = \frac{e_{a0}}{e_i} = K \prod_{r=1}^{r=n/2 \text{ or } (n+1)/2} \frac{(p - \sigma_{ar})}{(p + \sigma_{ar})}$$

(b) B network—

$$f_b(p) = \frac{e_{b0}}{e_i} = K \prod_{r=1}^{r=(n-1)/2 \text{ or } n/2} \frac{(p - \sigma_{br})}{(p + \sigma_{br})}$$

where K is a constant as yet undetermined.

6. Determine the maximum K that can be used such that the network is realized with RC elements only:

(a) Find values of p for which $(d/dp)[f_a(p)] = 0$.

(b) Substitute the negative values of p obtained in (a) into the function $f_a(p)/K$ obtaining a set of numbers whose magnitudes are greater than one. The maximum magnitude in this set is the reciprocal of K.

(c) Repeat (a) and (b) for $f_b(p)$. If K comes out different, then choose the smaller of the two. If n is even then the maximum K for each network should be the same.

From now on the design procedures for two networks are identical so we can drop the distinction between them. That is, $f_a(p)$ and $f_b(p)$ are both represented by $f(p)$.

7. (a) Find all of the solutions of the equation:

$$f(p) - 1 = 0.$$

There will be as many negative real solutions of the equation as the degree of the numerator of $f(p)$ [of course, second-order roots are possible and must be counted twice]. Call these σ_{01}, σ_{23}, σ_{32}, σ_{45}, σ_{54}, etc., such that $|\sigma_{01}| > |\sigma_{23}| > |\sigma_{32}| > |\sigma_{45}|$ etc.

(b) Repeat for the equation

$$f(p) + 1 = 0$$

obtaining roots σ_{12}, σ_{21}, σ_{34}, σ_{43}, etc. such that $|\sigma_{12}| > |\sigma_{21}| > |\sigma_{34}| > |\sigma_{43}|$ etc.

8. Construct two impedance functions of the form:

$$Z_x = K_x \frac{(p - \sigma_{x2})(p - \sigma_{x4})(p - \sigma_{x6})(\quad)(\quad)}{(p - \sigma_{x1})(p - \sigma_{x3})(p - \sigma_{x5})(\quad)(\quad)}$$

$$Z_y = K_y \frac{(p - \sigma_{y2})(p - \sigma_{y4})(p - \sigma_{y6})(\quad)(\quad)}{(p - \sigma_{y1})(p - \sigma_{y3})(p - \sigma_{y5})(\quad)(\quad)}$$

where $\sigma_{y1} = \sigma_{01}$, $\sigma_{y2} = \sigma_{12}$ and $\sigma_{x1} = \sigma_{21}$ or $\sigma_{y2} = \sigma_{21}$ and $\sigma_{x1} = \sigma_{12}$, $\sigma_{y3} = \sigma_{23}$ and $\sigma_{x2} = \sigma_{32}$ or $\sigma_{y3} = \sigma_{32}$ and $\sigma_{x2} = \sigma_{23}$, etc. Continue this alternating the process until the last root is left. If this last value is a solution of $f(p) - 1 = 0$ then it is a pole of Z_y ($p - \sigma$ factor in the denominator of Z_y). If it is a solution of $f(p) + 1 = 0$, then it is a pole of Z_x. The constants are related by

$$\frac{K_x}{K_y} = \frac{1 - K}{1 + K}.$$

The absolute value of K_x is arbitrary and is determined from practical considerations of ranges of element values available.

9. The network load capacity is:

$$C_L \leq \frac{1}{K_y \pi f_l}.$$

To find the load conductance evaluate

$$G_x = -\frac{1}{K_x}\frac{\sigma_{x1}\sigma_{x3}\sigma_{x5}\cdots}{\sigma_{x2}\sigma_{x4}\sigma_{x6}\cdots}$$

$$G_y = -\frac{1}{K_y}\frac{\sigma_{y1}\sigma_{y3}\sigma_{y5}\cdots}{\sigma_{y2}\sigma_{y4}\sigma_{y6}\cdots}.$$

If $G_x < G_y$ then $G_L = 2G_x$, but if $G_x > G_y$ then $G_L = 2G_y$.

10. Find element values:

(a) We have

$$Z_x(p) = K_x \frac{N(p)}{D(p)}$$

$$Z_{x1}(p) = \frac{K_x N(p)}{D(p) - \dfrac{K_x}{2}(G_L + pC_L)N(p)}.$$

(b) Factor the denominator of $Z_{x1}(p)$ and expand in partial fraction form:

$$Z_{x1}(p) = R_{x0} + \frac{K_{x1}}{(p - p_{x1})} + \frac{K_{x2}}{(p - p_{x2})} + \cdots.$$

(c) Obtain element values:

$$C_{xr} = \frac{1}{K_{xr}2\pi f_l} \qquad r = 1, 2, 3, \text{etc.}$$

$$R_{xr} = \frac{-1}{p_{xr}C_{xr}2\pi f_l}.$$

(d) Repeat (a), (b), and (c) for Z_y:

R_0 and p_1 may be zero. If p_1 is zero, then R_1 is infinite, i.e., open circuit.

(e) Schematic diagram (Fig. 6).

(f) Give K_x a value such that the values of elements are practical. Try to keep the minimum capacity at least 100 $\mu\mu$f and the maximum resistance less than 1 megohm (Fig. 8).

NUMERICAL EXAMPLE

Requirements

$f_l = 300$ cps
$f_h = 3{,}000$ cps
$\epsilon = 1.1$ degrees.

1. $n = 4$.
2. (a) $k' = 0.1$
   (b) $k = 0.994987$
   (c) $l = 0.00062814$
   (d) $q' = 0.00062814$
   (e) $q = 0.262196$.
3. (a) $\phi_{a1} = 11.25$ degrees
   $\phi_{a2} = 56.25$ degrees
   (b) $\phi_{b1} = 33.75$ degrees
   $\phi_{b2} = 78.75$ degrees
   (c) $\phi_{a1}' = 2.6411$ degrees
   $\phi_{a2}' = -2.91190$ degrees
   (d) $\phi_{b1}' = 2.91190$ degrees
   $\phi_{b2}' = -2.6411$ degrees.
4. (a) $\sigma_{a1} = 0.47875$
   $\sigma_{a2} = 5.2967$
   (b) $\sigma_{b1} = 1.8879$
   $\sigma_{b2} = 20.8877$.
5. (a) $f_a(p) = K\dfrac{(p - \sigma_{a1})(p - \sigma_{a2})}{(p + \sigma_{a1})(p + \sigma_{a2})}$
   (b) $f_a(p) = K\dfrac{(p - \sigma_{b1})(p - \sigma_{b2})}{(p + \sigma_{b1})(p + \sigma_{b2})}$.
6. $K = 0.28912$.

A *network:*

7. (a) $\sigma_{01} = -10.2255$
   $\sigma_{23} = -0.24799$
   (b) $\sigma_{12} = \sigma_{21} = -1.5924$.

$$8.\quad Z_x = \frac{K_x}{p + 1.5924}$$

$$Z_y = \frac{K_x(p + 1.5924)}{0.55144(p + 10.2255)(p + 0.24799)}.$$

$$9.\quad C_L = \frac{1.10288}{K_x 2\pi f_l} \qquad G_L = \frac{1.7563}{K_x}.$$

$$10.\quad Z_{x1} = \frac{2.2294K_x}{(p + 1.5924)}$$

$$Z_{y1} = 0.2488K_x + \frac{0.39620K_x}{p}$$

$R_{x0} = 0$ $\qquad$ $R_{y0} = 0.24880K_x$
$R_{x1} = 1.4000K_x$ $\qquad$ $R_{y1} = \infty$ (open circuit)

$$C_{x1} = \frac{0.44856}{K_x 2\pi f_l} \qquad C_{y1} = \frac{2.5240}{K_x 2\pi f_l}$$

$$C_{x1} = \frac{0.00023797}{K_x} \qquad C_{y1} = \frac{0.0013390}{K_x}$$

$$C_L = \frac{0.00058510}{K_x}.$$

B *network:*

7. (a) $\sigma_{01} = -40.324$
   $\sigma_{23} = -0.97795$
   (b) $\sigma_{12} = \sigma_{21} = -6.2797$.

$$8.\quad Z_x = \frac{K_x}{p + 6.2797}.$$

$$Z_y = \frac{K_x(p + 6.2797)}{0.55144(p + 40.324)(p + 0.97795)}.$$

$$9.\quad C_L = \frac{1.10288}{K_x 2\pi f_l} \qquad G_L = \frac{6.9258}{K_x}.$$

$$10.\quad Z_{x1} = \frac{2.2294K_x}{p + 6.2797}$$

$$Z_{y1} = 0.06309K_x + \frac{0.39620K_x}{p}$$

$R_{x0} = 0$ $\qquad$ $R_{y0} = 0.06309K_x$
$R_{x1} = 0.35501K_x$ $\qquad$ $R_{y1} = \infty$

$$C_{x1} = \frac{0.44856}{K_x 2\pi f_l} \qquad C_{y1} = \frac{2.5240}{K_x 2\pi f_l}$$

$$C_{x1} = \frac{0.00023797}{K_x} \qquad C_{y1} = \frac{0.0013390}{K_x}$$

$$C_L = \frac{0.00058510}{K_x}.$$

The network circuit diagram is shown in Fig. 8. The value of K_x was chosen so as to make the lowest resistance in each network 100,000 ohms. This results in the following element values:

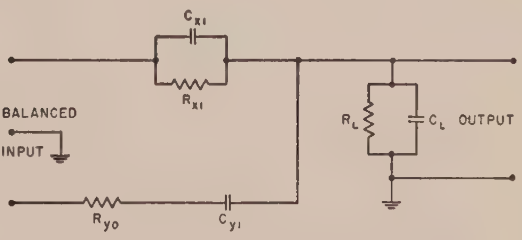


Fig. 8—Schematic diagram of example.

A *network:*	B *network:*
$K_x = 4.01924 \times 10^5$	$K_x = 1.58498 \times 10^6$
$R_{x1} = 562.7\ K\Omega$	$R_{x1} = 562.7\ K\Omega$
$R_{y0} = 100.0\ K\Omega$	$R_{y0} = 100.0\ K\Omega$
$R_L = 228.9\ K\Omega$	$R_L = 228.9\ K\Omega$
$C_{x1} = 592.1\ \mu\mu f$	$C_{x1} = 150.1\ \mu\mu f$
$C_{y1} = 3{,}331\ \mu\mu f$	$C_{y1} = 844.8\ \mu\mu f$
$C_L = 1{,}456\ \mu\mu f$	$C_L = 369.2\ \mu\mu f$.

CONSTRUCTION AND ALIGNMENT

These networks require careful construction and precise alignment if the phase-difference tolerance ϵ is within one degree. As a rule of thumb, the elements values should be within δ per cent of their design values where δ is the expected alignment error in degrees. These networks have been successfully built and tested for values of ϵ less than 0.2 degree.

Parallel combinations of resistance and capacitance form the basic impedance units of the network. This is a good combination to build because it allows for the shunt capacity of precision-wire-wound resistors and the shunt conductance of capacitors. Taking into account these second-order parasitic effects makes precise alignment of the parallel RC combination possible.

The networks can be built quite compactly, but care should be taken in the layout of components to minimize parasitic capacities between network nodes not having design capacities between them. The resistances can be adjusted to the proper values on a dc bridge. These values of resistance should take into consideration the effective shunt conductance of their companion capacitors near the center of the audio band.

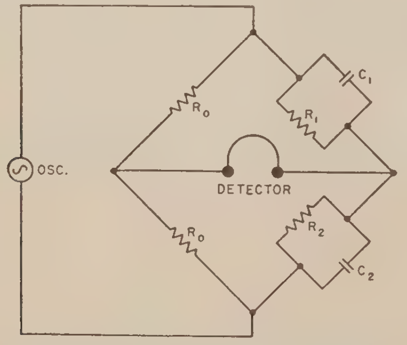


Fig. 9—Bridge circuit used for alignment.

Each parallel RC combination should have a trimmer capacitor across it for final alignment. A nonfrequency-selective bridge of the type shown in Fig. 9 is used to align each combination.

First the resistances R_1 and R_2 are removed from the bridge and a standard capacitor is set to the design value of the capacitance to be aligned and is put in the C_2 position. C_1 is adjusted for bridge balance, and the standard capacity is replaced by the RC combination to be aligned. Next R_1 is added to the circuit and the bridge is again balanced by adjusting R_1 and the trimmer capacitor of the network. This will give the correct alignment of the circuit if the addition of R_1 did not change the effective capacity C_1. However, the addition of any physical resistance across C_1 will add some additional capacitance to C_1. Therefore R_1 should have its effective shunt capacity measured as a function of resistances, and for any resistance setting the capacitor C_1 should be reduced by the appropriate amount.

The networks are conveniently driven by transformers having their secondaries very accurately center-tapped. A cathode follower provides a good low-impedance driving source for the transformer. The output of the network should work into the grid of a vacuum tube to provide a controlled load for the network. The load impedance should be aligned taking the input capacity of the tube into account.

ACKNOWLEDGMENT

This paper resulted from work done under the direction of Prof. D. F. Tuttle, Jr., Stanford University, Stanford, Calif.

BIBLIOGRAPHY

S. Darlington, "Realization of constant phase difference," *Bell Sys. Tech. Jour.*, vol. XXIX, pp. 94–104; Jan., 1950.

R. B. Dome, "Wideband phase shift networks," *Electronics*, vol. 19, pp. 112–115; Dec., 1946.

D. G. C. Luck, "Properties of some wide-band phase-splitting networks," PROC. I.R.E., vol. 37, pp. 147–151; Feb., 1949.

H. J. Orchard, "Synthesis of wideband two-phase networks," *Wireless Eng.*, pp. 72–81; March, 1950.

H. J. Orchard, "The synthesis of rc networks to have prescribed transfer functions," PROC. I.R.E., vol. 39, pp. 428–432; April, 1951.

W. Saraga, "The design of wide-band phase splitting networks," PROC. I.R.E., vol. 38, pp. 754–770; July, 1950.

Ultra-Low-Frequency, Three-Phase Oscillator*

GILBERT SMILEY†

Summary—**This paper describes the design of a three-phase oscillator covering the range from 0.01 to 1,000 cycles per second. The problems peculiar to this frequency range, and their solutions, are discussed. Certain advantages inherent in three-phase operation are explained.**

THE RECENT rapid growth of the geophysical, servomechanisms and other fields concerned with low-frequency phenomena has resulted in a demand for improved instrumentation. Accurate measurements of gain, attenuation and phase shift over the ultra-low-frequency band are essential for evaluation of system and component performance. While no exact limits have, as yet, been set for the ulf band, it may be assumed to extend from a low of approximately 0.01 cps to a high not exceeding 1 kc per second.

A basic tool for such measurements is an oscillator, closely settable to any desired frequency within the ulf band, having high purity of waveform and good stability versus time and supply fluctuations.

A major factor in ulf oscillator design is the size, and cost, of the frequency-determining networks required to secure oscillations with single cycle periods of the order of 100 seconds. Moreover, frequency-determining components must be linear, in the interest of waveform purity.

Nonlinearities that might be tolerated at audio-frequencies are all too apt to prove troublesome at ulf. Interfacial polarization in mica dielectrics, for example, assumes serious proportions at frequencies below 20 cps. Considerable ingenuity must be exercised to surmount such difficulties if a costly, brute-force approach is to be avoided.

Perhaps the most obvious solution of this problem and, certainly, one of the most effective, is to put the "Miller Effect"[1] to work. The deliberate use of "Miller Effect" capacitance multiplication was recommended and suggested by the work of Peterson[2] on adjustable audio-frequency filters.

Because inductors to operate at such low frequencies seemed all but unattainable, it was decided to explore the possibilities of a phase-shift oscillator using three identical RC networks.[3] Each network was to consist of a polystyrene capacitor and a stable resistor. "Miller Effect" multiplication would be used to keep the size, and cost, of these components within reason.

Fig. 1 is a greatly over-simplified circuit diagram of the oscillator, presented to show the principal advantages shorn of the clutter of circuitry required for a working model. Note that the three RC networks and their associated circuits are symmetrically disposed in a three-phase wye about the power supply, center.[4] Since the algebraic sum of the phase currents at the neutral of a balanced three-phase wye is zero, no phase currents of oscillator frequency traverse the power supply. *Thus the oscillator is independent of power supply impedance. Conversely, the oscillator is independent of power-supply fluctuations provided these are of insufficient amplitude to alter the operating parameters of the tubes.* Because of this, the power supply needs but a bare minimum of regulation, filtering and by-passing.

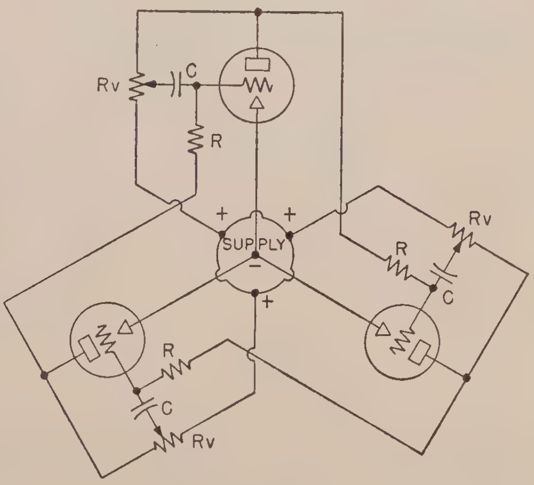


Fig. 1.

The oscillator is, basically, a three stage, re-entrant, dc amplifier. Oscillation occurs at that frequency for which the phase shift is 60 degrees in each of the three identical RC networks. At this frequency, each network attenuates the signal by a factor of 2. The dc loop gain must be at least 2^3, or 8. At dc (zero frequency) there is no RC phase shift, so the dc loop gain yields a degeneration of 18 db, making the system exceptionally stable against dc drift.

The plate circuit voltage-dividers, rv, are ganged to effect tuning by varying the "Miller Effect" gain. Assuming a minimum voltage gain of 2 per triode, the system shown would have a 3 to 1 tuning range, and, for the lowest frequency, the capacitors need be but one-third the value required were the "Miller Effect" omitted.

---

* Decimal classification: R355.911.5. Original manuscript received by the Institute, May 25, 1953; revised manuscript received, October 6, 1953.

† General Radio Co., Cambridge, Mass.

[1] J. M. Miller, Bureau of Standards Scientific Paper, no. 351; June 11, 1919.

[2] A. P. G. Peterson, *Proc. NEC*, vol. V, pp. 550–555; September 26–28, 1949.

[3] H. W. Nichols, U. S. Patent No. 1,442,781; January 16, 1923.

[4] B. Van der Pol and J. Van der Mark, U. S. Patent No. 2,024,489; December 17, 1935.

The circuit of Fig. 1 is, obviously, impractical. It does serve to illustrate certain features inherent in the dedesign. These are:

1. A three-phase, wye-connected oscillator is remarkably independent of its power supply.
2. The circuit is exceptionally stable against dc drift.
3. The circuit does not require costly, low-frequency, blocking, coupling, or by-pass capacitors.
4. The size, and cost, of the frequency-determining networks is kept down by the use of the "Miller Effect."

Fig. 2 shows one phase of the actual oscillator. As all phases are identical, a single phase serves to illustrate the techniques employed.

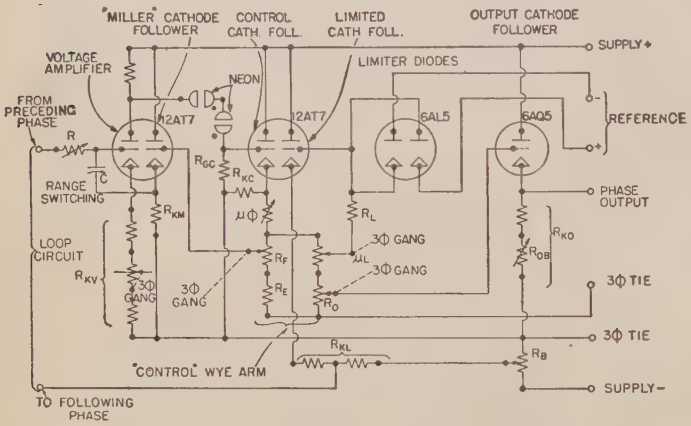

"MILLER" CATHODE FOLLOWER
CONTROL CATH. FOLL.
LIMITED CATH FOLL.
OUTPUT CATHODE FOLLOWER
SUPPLY+
VOLTAGE AMPLIFIER
LIMITER DIODES
NEON
FROM PRECEDING PHASE
12AT7
12AT7
6AL5
6AQ5
REFERENCE
R
RGC
RKC
C
RANGE SWITCHING
RKM
μΦ
RL
PHASE OUTPUT
RKO
3Φ GANG
ROB
LOOP CIRCUIT
RF
μL
3Φ GANG
RKV
3Φ GANG
3Φ GANG
RE
RO
3Φ TIE
3Φ TIE
RKL
RB
"CONTROL" WYE ARM
SUPPLY−
TO FOLLOWING PHASE

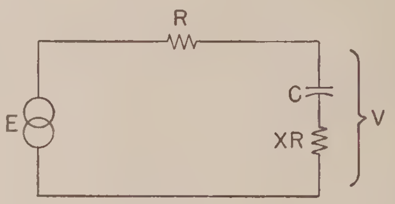
Fig. 2.

The voltage amplifier plate is coupled to the "Control" cathode follower grid by two neon tubes in series. These serve as a "dc capacitor," satisfying plate and grid voltage requirements from a reasonable supply voltage.

The "Control" cathode feeds a network which comprises one arm of a wye-connected load. The other two similar arms are in the remaining two phases; all three being tied together to complete the wye. If the "Control" cathodes in each phase are in dc balance, no dc potential differences will exist in the wye structure and bias relationships will be unaffected by slider adjustments. Individual phase gain controls, $\mu\phi$, permit balancing of the ac components applied to the wye. Ac voltage increases on all the ganged units in the "Control" network as the sliders move away from the wye junction (tie).

The "Control" network feeds three cathode followers. The frequency control, R_F, applies voltage to the "Miller" cathode follower for "Miller Effect" tuning. The loop gain control, μ_L, adjusts the voltage applied to the "Limited" cathode follower grid through a limiting network, and thence to the input of the next phase through a voltage dividing network, R_{KL}. The output control, R_0, feeds the grid of the phase output tube.

The "Miller Effect" cathode follower serves to keep the effective resistance in series with the phase-shift capacitor, "C," at a low value. Fig. 3 shows a phase-shift RC network with certain pertinent equations and derivations. *If the frequency for 60 degree phase shift is to stay within 1 per cent of the value computed from "R" and "C," "x" cannot exceed 0.0033.* In Fig. 2 the effective value of "*xR*" is 150 ohms or less, and the minimum value of "*R*" is 47 kilohms.



For 60 degree phase-shift

$$\omega CR=\sqrt{3},\ X=0$$

$$\omega CR=\frac{1\pm\sqrt{1-12(X\times X^2)}}{2\sqrt{3}(X+X^2)},\ X \text{ is finite}$$

For 1 per cent frequency change

$$1.01\sqrt{3}=\frac{1\pm\sqrt{1-12(X+X^2)}}{2\sqrt{3}(X+X^2)}$$

$$X=0.0033 \text{ maximum.}$$

Fig. 3.

Fig. 4 is an equivalent circuit of the three voltage amplifiers. The wye-connected voltage dividers in the cathode circuits have interconnected sliders, which, because they all move together, do not disturb the dc balance, if the system is initially balanced. The interconnection does, however, serve as an adjustable junction for the wye, thus providing a means for altering the ac cathode resistance, and, hence, the gain, without upsetting dc balance.

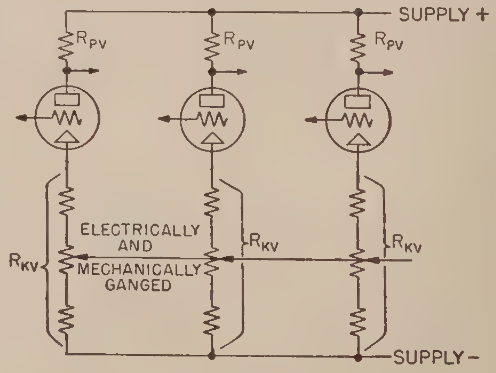

SUPPLY +
RPV
RPV
RPV
ELECTRICALLY AND MECHANICALLY GANGED
RKV
RKV
RKV
SUPPLY −

Fig. 4.

In the oscillating condition, amplitude will build up until limited by nonlinearities, which, if left to chance, may result in distortion in excess of acceptable limits. Accordingly, a deliberate limiting system is used, Fig. 5. The phase voltages, "*E*," are the equivalent of the output of the ganged loop gain controls, μ_L. Voltages, "*V*," represent the grid voltages of the “limited” cathode followers. As soon as the maximum phase voltage difference exceeds the “Reference” voltage, the six phase rectifier will conduct, effectively loading the limiting resistors and reducing “*V*” with respect to “*E*.” The resultant loading of the limiting resistors causes a “pinching” of the waveform, Fig. 6. This symmetrical “pinching” introduces odd harmonics, only, which harmonics are of comparatively low amplitude even during quite severe limiting. *The prototype oscillator, properly adjusted, operates with less than 0.1 per cent content for any harmonic, with effective limiting.*

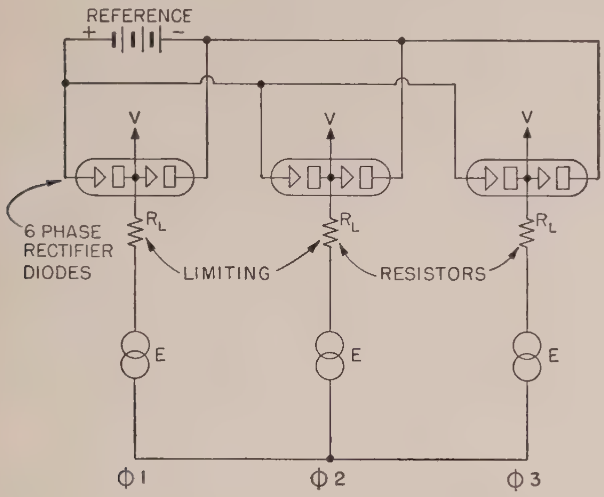


Fig. 5.

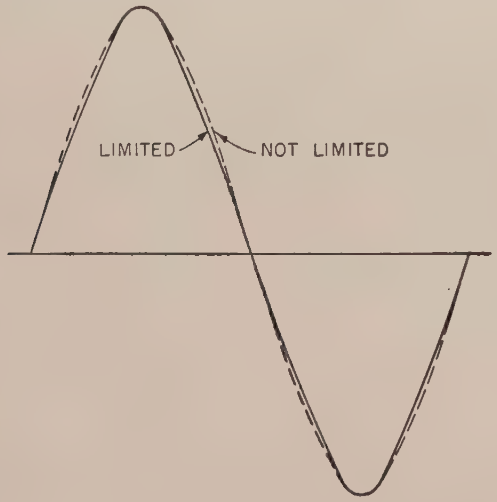


Fig. 6.

Fig. 7 illustrates another use of the six-phase rectifier principle, here to secure acceptable output level indication at very low frequencies without introducing the unbearably sluggish response consequent upon a time-constant circuit. Since the ratio of maximum to minimum instantaneous output voltage is but 1.15 in a six-phase rectifier, the meter response is governed solely by its own ballistics. This does result in meter pulsations for the lower frequency ranges, but visual averaging is reasonably accurate and the indication provided is far better than no indication at all, or one so sluggish as to be unuseable.

A final, promising feature of three-phase operation lies in the possibility of obtaining an output voltage adjustable as to phase and magnitude with reference to a fixed voltage, using resistive components alone. *Thus it is possible to measure transmission and phase performance without reactive components in the measuring circuit.* Such measurements require no frequency corrections. Experimental work along these lines has been most encouraging.

The remainder of the circuitry is conventional in most respects. The “Miller Effect” tuning covers a little more than a decade, so a ganged “Frequency Multiplier” switches successive values of “*R*” and “*C*” to cover the five decades between 0.01 and 1,000 cps.

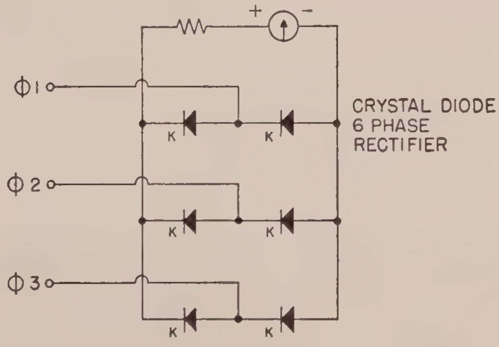
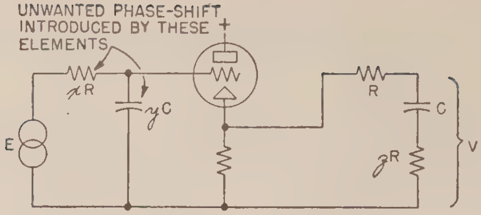


Fig. 7.

The existence of unwanted phase-shift in circuit elements other than the phase-shift networks proper, if of appreciable magnitude, has two serious effects. It alters and limits the frequency range, upsetting calculated calibrations. It increases the loop gain at oscillating frequency, overburdening the limiter.

If the oscillator must cover a wide frequency range, the obvious approach of limiting impedance levels and distributed capacitances may be inadequate. Fortunately this is a case of one man’s poison becoming another man’s meat, to mix a metaphor. The deliberate inclusion of resistance in series with the capacitance element of the RC networks, previously discussed as a disadvantage, may be used exactly to offset unwanted phase shift.

Fig. 8 shows two cascaded phase-shift networks. For simplicity, the gain of the cathode follower is assumed to be unity. The left-hand network contributes the unwanted phase-shift. *If the coefficient, “z,” of a resistance in series with the true phase-shift capacitor, “C,” equals the product of the coefficients “x” and “y” of the unwanted phase shift elements, the system will behave as a simple RC network. To restore and bring back initially computed performance based on “R” and “C” alone, “R” must be reduced and lessened by multiplication by 1—“z.”* “z,” of course, is, in this case here, no longer limited in



$$\begin{cases} \text{Computed from } C,\ R \quad \dfrac{E}{V}=1+j\omega CR \\ \text{If } z=xy \quad \dfrac{E}{V}=1+j\omega CR(1+z). \end{cases}$$

Fig. 8.

value by the considerations of a single phase-shift network. Once this correction has been made and applied, the "Miller Effect" tuning varies "zR" and "C" together, maintaining and sustaining the correct relationship over the band.

Build-up of oscillation following warm-up or switching transients can be painfully slow-moving in true oscillators operating at ultra low frequency. However, to overcome and help cure this difficulty, a penal switch is provided, which, when momentarily depressed, introduces an overload transient into one phase. The limiter then operates upon the transient so definitely and effectively that steady state operation occurs within one cycle.

Any true oscillator circuit may be regenerated as a highly selective, peaked, tuned filter. This oscillator is no exception. As in all selective devices, there is an increasing tendency to "ring," as regeneration and selectivity are increased. However, stable and responsible operation, with rejection ratios in excess of 50 decibels for a 2/1 frequency shift, has been repeatedly obtained again and again. The response characteristic is reminiscent of an extremely high-Q, series-resonant circuit. Input terminals for this service are necessarily provided.

A Method of Solving Very Large Physical Systems in Easy Stages*

GABRIEL KRON†

***Summary*—Physical systems with a very large number of variables (say with tens of thousands) may be solved with available digital computers by tearing the system apart into a large number of small subdivisions. After solving each subdivision separately, the partial solutions are interconnected by a set of transformations so as to obtain the exact solution of the original system. Among the many advantages of the tearing method is the reduction of the amount of original calculations to a small fraction of about $2/n^2$, where n is the number of subdivisions. Another advantage is the reduction of the number of nonzero elements in inverse matrices to a fraction smaller than $1/\sqrt{n}$. The same labor saving appears also in smaller systems using slide-rule calculations. This paper illustrates the solution of Maxwell two-dimensional field-equations by tearing their electric-circuit models apart into a convenient number of subdivisions.**

Introduction

Method of Tearing

THE PURPOSE of this paper is to call the attention of radio engineers to a novel method of solving physical problems with a very large number of variables rapidly and in rather easy stages. The method consists of tearing the original physical system apart into a large number of component systems, so that each part becomes isolated from the other parts. Next, each partial system is solved independently, as if the other partial systems were nonexistent. Afterward, the component *solutions* themselves are interconnected by a set of transformations to give the solution outright of the entire system. The remaining work consists of the elimination or solution of the comparatively few constraints that appear at the cuts. The concept of "physical system," that can be torn apart, runs the whole gamut of physical sciences and includes both linear and —with certain precautions—nonlinear systems.

For a simple illustration this paper employs the solution of the partial differential equations of Maxwell, or rather the solution of their two-dimensional electric-circuit model. A more general illustration has already appeared in connection with solving the partial differential equation of Poisson having about 400 variables by tearing the entire system apart into eleven parts. A more detailed philosophy of the method of tearing has also been discussed.[1] Actual numerical calculations have also been published for studying the losses in the ex-

---

* Decimal classification: 510. Original manuscript received by the Institute, June 1, 1953; revised manuscript received September 1, 1953. Condensed from *Trans. I.R.E.*, PGCT-2, December, 1953.

† Consulting engineer, General Electric Co., Schenectady, N. Y.

[1] G. Kron, "A set of principles to interconnect the solutions of physical systems," *Jour. Appl. Phys.*, vol. 24, pp. 965–980; August, 1953.

tended transmission systems of several interconnected power companies covering several States.[2,3]

The loss studies mentioned also illustrate the tearing apart of a physical system whose description requires far more than a set of linear algebraic equations $\mathbf{I}=\mathbf{YE}$. In transmission system studies the usual concepts of current and impedance do not appear. Their role is replaced by the far more difficult concepts of real power and loss-coefficient, whose establishment requires a series of assumptions and transformations. Moreover, the final results are stated in a form that represents the most economic operating conditions of the entire transmission system. In general it was found in connection with combined steam and hydroelectric system studies that extensive problems of the Calculus of Variations lend themselves readily for solution by the method of tearing.

THE FIELD EQUATIONS OF MAXWELL

Although the solutions of the field equations of Maxwell are believed to be more involved than those of Poisson's equation (using either analytical or difference-equation methods), it so happens that in the method of tearing the solution difficulties are interchanged (for two-dimensional problems at least). *The steps for solving the steady-state electromagnetic field are much simpler than the steps involved in solving a steady heat-flow*, even though the electric-circuit model configuration controverts this statement. The simplification is due to the fact that the ground points of all isolated portions of the electromagnetic field are at the same potential. The interconnection of Maxwellian circuits involves only conventional shunt and series connections, and dispenses with the unfamiliar "interchange" and "sneak" paths needed in interconnecting the Poisson circuits.

The reader will be assumed to have some fleeting acquaintance with the concepts of adding, multiplying, and inverting matrices without, however, remembering the actual rules. The accompanying tensorial concepts of transformations will be stated as needed, without any attempt at justification. Constant reference will be made, however, to another text by the author[4] for more detailed treatment or proof of the more important statements.

ADVANTAGES OF TEARING

Several advantages may be claimed for the method of solving piecemeal well-nigh any type of extensive physical system by tearing, as compared to conventional methods of solving an entire problem as one unit. The following claims refer to exact and explicit solutions and not to iterative or relaxation types of solutions. (Of course the method of tearing may also be adapted to these latter types of solutions.)

a. Existing digital computers may now be used to solve problems with an extremely large number of variables that could have not been touched before. If a computer can solve a maximum of say 100 equations within a reasonable time, it can also solve a set of say 10,000 equations by tearing the corresponding physical system (not the equations) into one hundred parts.

b. The accuracy of the solutions and the number of necessary significant figures depends now only on the size of the subdivisions (and nature of cuts) and no longer on the size of the original system torn apart.

c. The amount of computation involved in the solution is considerably reduced. For instance, by dividing a physical system with an equation $\mathbf{I}=\mathbf{YE}$ into n parts, its inverse calculation $\mathbf{E}=\mathbf{ZI}$ is reduced by a factor of about $2/n^2$. This reduction in computation is equally maintained whether a slide-rule, desk-calculator, low-speed, or high-speed digital computer is employed.

d. If several or all of the component subdivisions are identical, the amount of reduction increases proportionately. (Conventional methods of solution cannot profit by the similarity of the component parts of a physical system.)

e. In solving a set of N equations, the conventional inverse usually involves N^2 elements. The method of tearing introduces a new type of inverse (called "orthogonal" inverse) in which the number of nonzero elements are reduced to a small fraction of N^2, say to $N^2/\sqrt{n}$ where n is the number of subdivisions. In the example worked out[1] where a system with 400 variables is divided into 11 parts, the 160,000 elements of the conventional inverse are reduced to about 30,000—a reduction to less than one-fifth. In each new set of numerical solution the amount of computation is reduced to this fraction.

f. If a system already solved is altered in any manner, say is increased or reduced in size, the solution of the altered system need not be started from scratch. Only the solutions of the altered portions are changed, retaining the rest of the solutions unchanged. That is, solutions can participate in the same type of evolutionary growth that the physical systems themselves may undertake.

g. Solutions of particular problems may be filed away for future use in connection with still larger problems. It is possible to store solutions of standardized parts in file cabinets in the same manner as standardized manufactured products are stored in warehouses. Entirely new problems may be solved by simply interconnecting partial solutions already available. Thus, the method of tearing opens up the possibility of mass production and mass consumption of solutions.

h. Practically all steps in the method of analysis are based on the properties of physical systems and not on the characteristics of mathematical equations. As a consequence, long drawn-out computations may be checked

---

[2] G. Kron, "Tensorial analysis of integrated transmission systems," *Trans. AIEE*, vol. 70, pp. 1239–1246; 1951; vol. 71, pp. 505–512; 1952; vol. 71, pp. 814–821; 1952; vol. 72, pp. 827–839; 1953.

[3] A. F. Glimn, L. K. Kirchmayer, and G. W. Stagg, "Analysis of losses in interconnected systems," *Trans. AIEE*, vol. 71, pp. 798–808; 1952; vol. 72; 1953.

[4] G. Kron, "Tensor analysis of networks," John Wiley and Sons, New York, N. Y., 1939.

at almost every step by *physical* tests (say by Kirchhoff's laws) and any mistake made by the machine, or in the coding, and even in the analysis itself, may easily be detected before the computation proceeds too far.

i. Most of the step in the tearing process consist of a sequence of addition, multiplication, and inversion of matrices. Since all high-speed digital computers have standard routines available for such sequence of steps, solution of extensive problems by method of tearing requires in general no special coding of the computers.

NEW CONCEPTS AND NEW TOOLS

The possibility of solving very large physical systems quickly and in easy stages with the aid of existing computers (digital or analog) is due to the integration of several apparently unrelated scientific concepts into a powerful analytical tool. A detailed description of these concepts can be found elsewhere.[1] Some of the salient points of integration may be pointed out as follows:

a. An electric-circuit (or any other) model of a physical system contains far more information about the system than a set of conventional equations do (be they difference equations or actual equations, such as the dynamical equations of Lagrange).

b. The concept of "orthogonal" network (or system) supplies all the missing variables and missing equations necessary to define a physical system.

c. The complementary concepts of tearing apart physical systems and interconnecting physical systems reduce the theory and solution of a large variety of physical systems to that of a comparatively few and simple basic elements.

d. The concepts of tearing and interconnection utilize many of the informations that are missing from conventional equations.

e. As the entire method of attack is based chiefly upon "physical" phenomena and not upon properties of mathematical equations, the concept of "tensor" as the mathematical representation of a physical entity becomes an indispensable analytical tool.

f. In addition to basic concepts (tensors and geometric objects) the laws and rules of Tensor Analysis supply a variety of transformations to pass freely from the "equations of state" of a physical system (or of its broken up components) to its "equations of solutions" and vice versa at arbitrary stages of the analysis.

g. The use of matrices allows easy numerical manipulation of a large number of variables.

h. The existence of high-speed digital computers permits the automatic *sequence* calculation of a series of matric operations such as addition, multiplication, and division (inversion).

A strong instinct toward a unified viewpoint of all physical phenomena and for the unity of all sciences greatly facilitates an understanding of the method of attack shown and discussed here, and its application to diverse physical phenomena.

An Example

To illustrate by a practical example the possibilities opened up by the method of tearing, the actual solution of the electric-circuit model of a cylindrical nuclear reactor will be cited. This circuit had 256 junction points and possessed the same geometrical configuration as the Maxwellian circuits of this paper. The problem was to find the inverse of a matrix with 256 rows and columns.

A Card Program Calculator was used that could invert a matrix with 16 rows and columns in about one hour and ten minutes. If a routine could have been worked out for the actual matrix, the inversion would have taken about 4,800 hours (1.17×16^3). Consequently, the equivalent circuit was subdivided into 16 parts, each with 16 junction points, so that each part could be separately solved on the CPC.

According to the above rule of thumb $(2/n^2)$ the time of inversion of the given matrix should have consumed about $4{,}800\ (2/16^2)=4{,}800/128=38$ hours machine time. Actually *the inversion of the 256×256 matrix took slightly less than 16 hours.* The extra saving was due to the identity of several of the subdivisions. Also the number of nonzero elements was 14,600, as against the $65{,}500=256^2$ nonzero elements of a conventional inverse. The ratio here is 1/4.5 as against $1/\sqrt{16}=1/4$ of the rule of thumb.

The original matrix had 8 significant figures. About 90 per cent of the inverse was accurate to 6 figures, and most of the rest to 5 figures. The last two 16×16 matrices had about 4-figure accuracy, which probably could have been improved. Theoretically the accuracy of the worst 16×16 matrix should have been equivalent to the rounding-off errors occurring in an inverse matrix with 56 rows and columns (not 256, but 56).

SOLUTION OF A SUBDIVISION

The Network Equations

Electric-circuit models of the electromagnetic field have been previously developed by the author.[5] They were discussed from various points of view of the radio engineer by Whinnery and Ramo,[6] McAllister,[7] and Shelkunoff.[8] Two high-frequency models have also been constructed at Stanford University.[9] Fig. 1, containing resistors, inductors, and capacitors, represents the field equations of Maxwell for a two-dimensional TE or TM wave in any curvilinear orthogonal reference frame.

$$\text{Curl}\ \mathbf{E} + \frac{\partial \mathbf{B}}{\partial t} = 0 \qquad \text{Div}\ \mathbf{B} = 0 \qquad (1)$$

---

[5] G. Kron, "Equivalent circuit of the field equations of Maxwell—I," PROC. I.R.E., vol. 32, pp. 289–299; May, 1944.

[6] J. R. Whinnery and S. Ramo, "A new approach to the solution of high-frequency field problems," PROC. I.R.E., vol. 32, pp. 284–288; May, 1944.

[7] J. F. McAllister, "Equivalent circuits of the electromagnetic field," *Gen. Elec. Rev.*, vol. 47, pp. 9–14; March, 1944.

[8] S. A. Schelkunoff, "Methods of electromagnetic field analysis," *Bell Sys. Tech. Jour.*, vol. 27, pp. 487–509; 1948.

[9] K. Spangenberg, G. Walters, and F. Schott, "Electrical network analyzers for the solution of electromagnetic field problems," PROC. I.R.E., vol. 37, pp. 724–729; July, 1949.

$$\text{Curl } \mathbf{H} = \frac{\partial \mathbf{D}}{\partial t} + \mathbf{I} \qquad \text{Div } \mathbf{D} = 0. \tag{2}$$

The network of Fig. 1 may actually assume any odd shape to represent cavity resonators, waveguides, radiation fields, and so forth.

The network configuration of Fig. 1 may also represent the partial differential equation

$$\text{Div } \mathbf{y} \text{ grad } \phi + a\phi + b = 0 \tag{3}$$

$$\frac{\partial}{\partial u}\mathbf{y}_u\frac{\partial \phi}{\partial u} + \frac{\partial}{\partial v}\mathbf{y}_v\frac{\partial \phi}{\partial v} + a\phi + b = 0,$$

where $\mathbf{y}$, a, and b are known complex functions of two independent real variables u and v.

The components of the matrix $\mathbf{y}$ with complex elements represent the *horizontal* admittances (in the plane of the paper) of Fig. 1; the complex scalar "a" represents the *vertical* admittances (connecting the planar coils to the ground). The complex scalar "b" represents the known currents I impressed at some of the junctions. The unknown ϕ represents the difference of potential E appearing between each junction point and the ground.

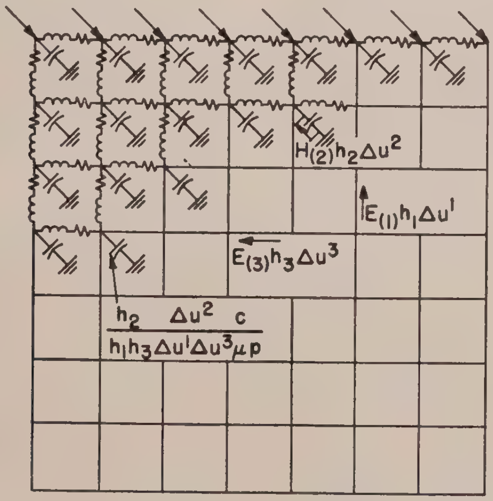


Fig. 1—Given network.

THE PROBLEM

Two problems arise:

a. Find the value of E at those junctions only where the known I are impressed.

b. Find E at all junctions.

The simpler first problem is investigated in detail. The *additional* steps needed for the second problem are only indicated.

It should be noted that if the partial differential equation (2) is replaced by a set of difference equations, the latter assumes the form $\mathbf{I}=\mathbf{YE}$, where $\mathbf{I}$ and $\mathbf{Y}$ are known and $\mathbf{E}$ is unknown. The problem is then to establish the inverse equations $\mathbf{E}=\mathbf{ZI}$ where $\mathbf{Z}$ is the inverse of $\mathbf{Y}$. Since $\mathbf{I}$ is known, therefore $\mathbf{E}$ may be calculated by multiplying the matrix $\mathbf{Z}$ with the vector $\mathbf{I}$.

THE SUBDIVISION

Let the network of Fig. 1 be subdivided into four parts, as shown in Fig. 2. In order to simplify the presentation, the simpler network of Fig. 3 will be studied in detail instead.

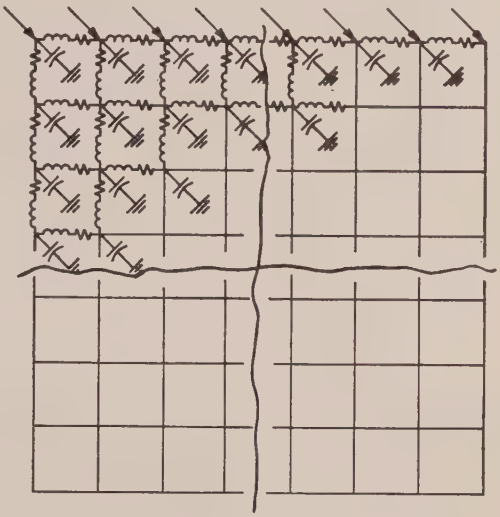


Fig. 2—Four subdivisions.

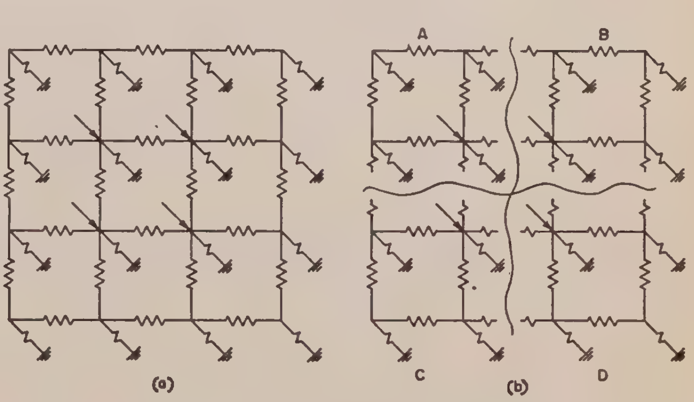


Fig. 3—Simple network assumed for illustration: (a) given network; (b) four subdivisions.

It will be assumed that the equation $\mathbf{I}=\mathbf{YE}$ of each subdivision has been solved as $\mathbf{E}=\mathbf{ZI}$ by *any* arbitrary method. If so desired each subdivision may be solved by the tensorial method, that is, by tearing it further apart into its ultimate components, the "coils."[10]

SOLUTION OF ONE SUBDIVISION

The resultant solutions $\mathbf{E}=\mathbf{ZI}$ of each subdivision assume the form

$$\begin{array}{c} \\ \left|\begin{array}{c} E_a \\ E_b \\ E_c \\ E_d \\ E_e \end{array}\right| \end{array} = \begin{array}{c} \left|\begin{array}{ccccc} I^a & I^b & I^c & I^d & I^e \end{array}\right| \\ \left|\begin{array}{ccccc} Z_{aa} & Z_{ab} & Z_{ac} & Z_{ad} & Z_{ae} \\ Z_{ba} & Z_{bb} & Z_{bc} & Z_{bd} & Z_{be} \\ Z_{ca} & Z_{cb} & Z_{cc} & Z_{cd} & Z_{ce} \\ Z_{da} & Z_{db} & Z_{dc} & Z_{dd} & Z_{de} \\ Z_{ea} & Z_{eb} & Z_{ec} & Z_{ed} & Z_{ee} \end{array}\right| \end{array}. \tag{4}$$

---

[10] G. Kron, "Tensor analysis of networks," *ibid.*, p. 86.

The equivalent circuit of the above *solution* is given in Fig. 4(a). It consists of five coils extending between the five junction points (at which **I** enters) and the ground point. The five coils are coupled by mutual impedances that are not shown on the figure.

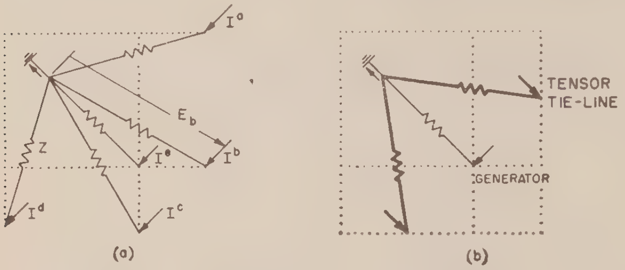


Fig. 4—Equivalent circuit of the component solution: (a) Scalar network; (b) tensor network.

TENSOR NETWORKS

In order to simplify the analysis and manipulation of a large number of simultaneous equations describing a physical system, the concept of matrix (or rather tensor) has been introduced, represented by a bold-face symbol. Each bold-face symbol such as **e** represents a large number of conventional numbers expressed along a large number of reference frames. It is possible to perform a long chain of reasoning in terms of tensors only.

Similarly, in order to simplify the analysis of a large variety of extensive electrical networks, it is possible to replace a large number of coils (each performing the same physical role) by one hypothetical coil, a so-called "tensor" coil, drawn bold-face in Fig. 4(b). Each bold-face coil is represented by a bold-face symbol, so that *a tensor equation may be said to represent the performance of a tensor network.*[11]

In Fig. 4(b) all boundary coils (tie-lines) leading to a boundary line are replaced by a "tensor tie-line." Similarly, all generators with known impressed **I** are replaced by a single bold-face "tensor generator." In the present example the tensor generator happens to have only one component; hence, it is drawn light-face.

INTERCONNECTION OF THE SUBDIVISIONS

The "Primitive" System (Frame 1)

Let four of the subdivisions of Fig. 4(a) be shown in Fig. 5. It is assumed that their solutions $\mathbf{E}=\mathbf{Z}\mathbf{I}$ have already been established. The combined equations of the four subdivisions (the "primitive" system) *before* interconnection may be written as $\mathbf{E}_1=\mathbf{Z}_{11}\mathbf{I}^1$.

$$\begin{array}{|c|} \\ \mathbf{E}_A \\ \mathbf{E}_B \\ \mathbf{E}_C \\ \mathbf{E}_D \end{array} = \begin{array}{|cccc|} \mathbf{I}^A & \mathbf{I}^B & \mathbf{I}^C & \mathbf{I}^D \\ \mathbf{Z}_{AA} & & & \\ & \mathbf{Z}_{BB} & & \\ & & \mathbf{Z}_{CC} & \\ & & & \mathbf{Z}_{DD} \end{array} . \qquad (5)$$

No mutual couplings exist between the subdivisions. Each matric equation, such as $\mathbf{E}_A=\mathbf{Z}_{AA}\mathbf{I}^A$, represents the five scalar equations calculated in (4).

Altogether there are 4×5=20 scalar equations, corresponding to the 20 coils appearing in the primitive network of Fig. 5(a). The corresponding tensor network is shown in Fig. 5(b).

The Simplicity of Interconnection

The present network of Fig. 5 is more complicated than the network representing Poisson's equations, as additional coils now appear that connect every junction of the planar network to the ground. Nevertheless the interconnection of the present type of Maxwell network is far simpler than the interconnection of the networks of Poisson. The simplicity is due to the fact that now the ground points assumed in each subdivision are at the same potential after interconnection. On the other hand in interconnecting the Poisson networks the ground-points (or load-points) of each subdivision assume different absolute potentials.

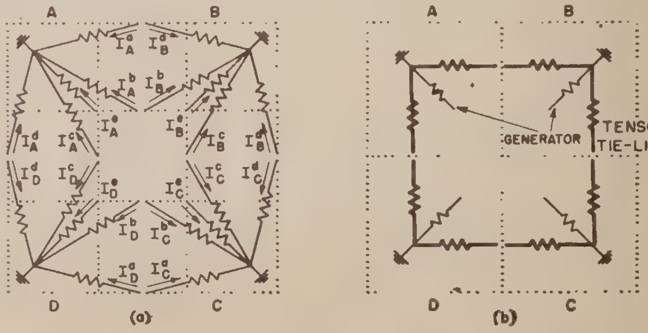


Fig. 5—The "primitive" solution (Frame 1): (Scalar networks; (b) tensor network.

That is to say, in interconnecting the Poisson networks it is necessary and desirable to introduce "interchange" paths to calculate and determine the differences of the ground potentials. *The interchange paths are not present in the Maxwell network* and the five successive transformations are thus lowered and reduced to only two transformations.

The Connection Tensor $\mathbf{C}_2^1$

As shown in Fig. 6, (page 685) now not only the neighboring tie-lines are connected in series, but also the several ground points are interconnected by lines with zero impedance. That is, now *every interconnected tie-line (8 in number) forms a circulating mesh through the ground,* as shown at the right of Fig. 6(a). (In the Poisson network one of the tie-lines connecting two subdivisions always forms an interchange path between two grounds at different potentials.)

The relation between the 20 "old" currents $\mathbf{I}^1$ of Fig. 5 and the 12 "new" currents $\mathbf{I}^2$ of Fig. 6(a) is[12] $\mathbf{I}^1=\mathbf{C}_2^1\mathbf{I}^2$ where

---

[11] *Ibid.*, p. 480.

[12] *Ibid.*, p. 137.

$$C_2^1 = \begin{array}{c|cccc|cccccccc}
 & A & B & C & D & 1_\alpha & 1_\beta & 2_\alpha & 2_\beta & 3_\alpha & 3_\beta & 4_\alpha & 4_\beta \\
\hline
A_a & & & & & -1 & & & & & & & \\
A_b & & & & & & -1 & & & & & & \\
A_c & & & & & & & & & & & & 1 \\
A_d & & & & & & & & & & & 1 & \\
A_e & 1 & & & & & & & & & & & \\
\hline
B_a & & & & & 1 & & & & & & & \\
B_b & & & & & & 1 & & & & & & \\
B_c & & & & & & & & -1 & & & & \\
B_d & & & & & & & -1 & & & & & \\
B_e & & 1 & & & & & & & & & & \\
\hline
C_a & & & & & & & & & -1 & & & \\
C_b & & & & & & & & & & -1 & & \\
C_c & & & & & & & & 1 & & & & \\
C_d & & & & & & & 1 & & & & & \\
C_e & & & 1 & & & & & & & & & \\
\hline
D_a & & & & & & & & & 1 & & & \\
D_b & & & & & & & & & & 1 & & \\
D_c & & & & & & & & & & & & -1 \\
D_d & & & & & & & & & & & -1 & \\
D_e & & & & 1 & & & & & & & &
\end{array}
= \begin{array}{c|cc}
 & j & m \\
\hline
A & C_1 & C_2 \\
B & C_3 & C_4 \\
C & C_5 & C_6 \\
D & C_7 & C_8
\end{array} \qquad (6)$$

The Interconnected System (Frame 2)

The equations of the interconnected system of Fig. 7 are $\mathbf{E}_2 = \mathbf{Z}_{22}\mathbf{I}^2$.

$$\mathbf{Z}_{22} = (\mathbf{C}_2^1)_t \mathbf{Z}_{11} \mathbf{C}_2^1 \qquad (7)$$

$$\mathbf{Z}_{22} = \begin{array}{c|cc}
 & \mathbf{j} & \mathbf{m} \\
\hline
\mathbf{j} & \begin{array}{c} C_{1t}Z_{AA}C_1 + C_{3t}Z_{BB}C_3 \\ + C_{5t}Z_{CC}C_5 + C_{7t}Z_{DD}C_7 \end{array} & \begin{array}{c} C_{1t}Z_{AA}C_2 + C_{3t}Z_{BB}C_4 \\ + C_{5t}Z_{CC}C_6 + C_{7t}Z_{DD}C_8 \end{array} \\
\mathbf{m} & \begin{array}{c} C_{2t}Z_{AA}C_1 + C_{4t}Z_{BB}C_3 \\ + C_{6t}Z_{CC}C_5 + C_{8t}Z_{DD}C_7 \end{array} & \begin{array}{c} C_{2t}Z_{AA}C_2 + C_{4t}Z_{BB}C_4 \\ + C_{6t}Z_{CC}C_6 + C_{8t}Z_{DD}C_8 \end{array}
\end{array} \qquad (8)$$

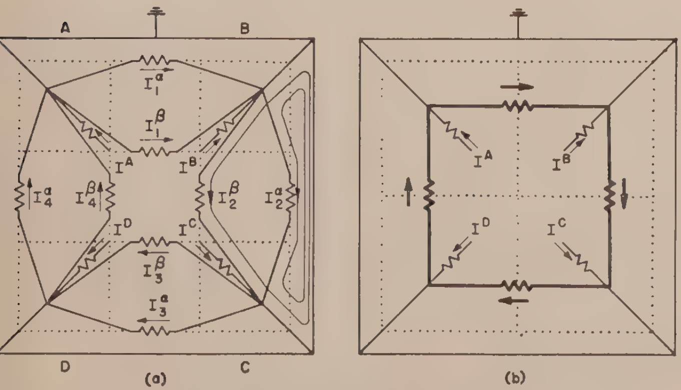


Fig. 6—The "interconnected" solution (Frame 2): (a) Scalar network; (b) tensor network.

The above equations are expressed in two groups. One group (4 scalar equations) along the junction pairs **j** and the other group (8 scalar equations) along the meshes **m**.

$$\begin{vmatrix} \mathbf{E} \\ 0 \end{vmatrix} = \begin{array}{|cc|} \mathbf{I} & \mathbf{i} \\ Z_1 & Z_2 \\ Z_3 & Z_4 \end{array} \qquad (9)$$

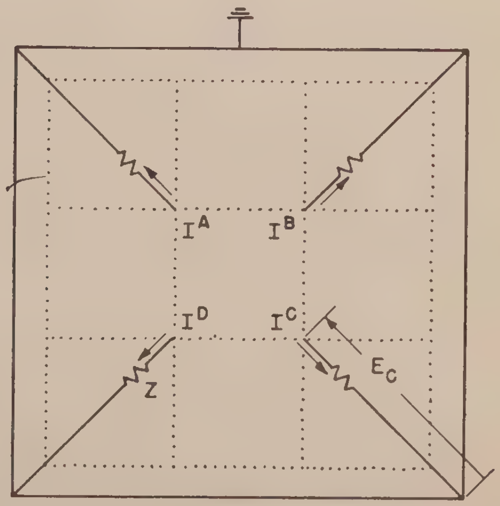


Fig. 7—Final solution (Frame 3).

The new voltage vector *after* interconnection is found $\mathbf{E}_2=(\mathbf{C}_2{}^1)_t\mathbf{E}_1$ as

$$\begin{array}{c|cccc|cccccccc} & & \mathbf{j} & & & & & & \mathbf{m} & & & & \\ \hline \mathbf{E}_2= & E_{Ae} & E_{Be} & E_{Ce} & E_{De} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{array}$$

That is, all mesh voltages become zero, since all ground points are short-circuited.

Elimination of Meshes (Frame 3)

The unknown 8 mesh currents **i** are eliminated by[13]

$$\mathbf{Z}_{22}{}' = \mathbf{Z}_1 - \mathbf{Z}_2\mathbf{Z}_4{}^{-1}\mathbf{Z}_3, \tag{10}$$

giving the solution of the resultant system of Fig. 7 as $\mathbf{E}_3=\mathbf{Z}_{33}\mathbf{I}^3$. There are only four scalar equations, representing the voltages **E** across the four junctions at which **I** is impressed.

SOLVING FOR THE MESH CURRENTS

Since the component matrices $\mathbf{Z}_1$, $\mathbf{Z}_2$ and $\mathbf{Z}_3$ of (9) are strongly diagonal with many zero off-diagonal elements, *it is preferable not to perform the elimination*, but to leave (8) in its given form. That is the solution of $\mathbf{I}=\mathbf{YE}$ is represented by the form

$$\mathbf{E} = (\mathbf{Z}_1 - \mathbf{Z}_2\mathbf{Y}^4\mathbf{Z}_3)\mathbf{I}. \tag{11}$$

For any given numerical **I**, the substitutions indicated in (11) are to be performed in succession.

The "orthogonal" inverse table may be represented as

$$\mathbf{Z}_{22}{}' = \begin{vmatrix} \mathbf{Z}_1 & \mathbf{Z}_2 \\ \mathbf{Z}_3 & \mathbf{Z}_4{}^{-1} \end{vmatrix} \tag{12}$$

differing from (9) by the presence of the constraint (mesh current) inverse $\mathbf{Z}_4{}^{-1}=\mathbf{Y}^4$. *The "orthogonal" inverse table is strongly diagonal and contains only a small fraction of the nonzero elements that exist in the conventional inverse matrix.*

Thus, another important consequence of the process of tearing is that *it requires far less computation to solve simultaneously for both forces and constraints, than to solve for the forces alone.*

CALCULATION OF JUNCTION POTENTIALS

In the example shown only some of the junctions have a current I impressed upon them. It was also assumed that the potentials E of those junctions that have no I, are of no interest. If the potentials of all junctions have to be known, then the number of assumed junction pairs in Fig. 4(a) is 8 instead of 5 and $(\mathbf{C}_2{}^1)_t$ assumes more columns. The steps are analogous to those given elsewhere.[14]

---

[13] *Ibid.*, p. 61.

[14] *Ibid.*, p. 128.

Radiation Resistance and Gain of Homogeneous Ring Quasi-Array*

H. L. KNUDSEN†

Summary—In a previous paper homogeneous ring quasi-arrays of tangential or radial dipoles were introduced, i.e. systems of dipoles arranged equidistantly along a circle, the dipoles being oriented in tangential or radial directions and carrying currents with the same amplitude, but with a phase that increases uniformly along the circle. Such quasi-arrays are azimuthally omnidirectional, and the radiated field will be mainly horizontally polarized and concentrated around the plane of the circle. In this paper expressions are obtained for the radiation resistance and the gain of homogeneous ring quasi-arrays of an infinite number of tangential or radial dipoles, and from the results arrived at conclusions are drawn as to the applicability of such antenna systems.

INTRODUCTION

IN A PREVIOUS PAPER[1] it was shown that an azimuthally omnidirectional antenna system with a field that is concentrated around the horizontal plane and with predominantly horizontal polarization may be obtained by placing equidistantly along a circle in the horizontal plane a number of tangential or radial dipoles and by feeding these dipoles with currents having the same numerical value but a phase that increases uniformly along the circle. An antenna system of this type will be called a homogeneous ring quasi-array of tangential or radial dipoles. In order that this ring quasi-array may be completely omnidirectional in the horizontal plane the number of dipoles must be infinitely large; this case is illustrated in Figs. 1(b) and

---

* Decimal classification: R-129. Original manuscript received by the Institute, August 28, 1953. The work described here was carried out at The Microwave Laboratory of The Royal Technical University of Denmark, Copenhagen, Denmark, and was made possible through the support granted by the Research Council of the Technical Sciences in Denmark. It forms part of a Doctor's thesis ("Bidrag til teorien for antennesystemer med hel eller delvis rotationssymmetri," 228 pp., Copenhagen, Denmark, 1953). Some sections of this thesis have already been published in American journals.

† The Microwave Laboratory, The Royal Technical University of Denmark, Copenhagen, Denmark.

[1] H. L. Knudsen, "The field radiated by a ring quasi-array of an infinite number of tangential or radial dipoles," PROC. I.R.E., vol. 41, pp. 781–789; June, 1953.

7(b). The current phase increases a whole number, H, times 2π during one revolution in the positive direction. When the increment of the current phase along the circle augments, the radiation pattern concentrates to an increasing degree into a narrow, disk-shaped bundle around the horizontal plane. At the same time the vertical component of the electric field strength decreases in relation to the horizontal component. These properties of homogeneous ring quasi-arrays of tangential or radial dipoles explain their practical applicability.

Expressions for the field components and a thorough discussion of the radiation pattern of homogeneous ring quasi-arrays are given in the above mentioned paper.[1] However, with a view to the complete understanding and description of these antenna systems it is desirable to have expressions for the radiation resistance and the gain of these antenna systems. The present paper is devoted to the derivation and discussion of such expressions. In order to simplify the calculations the number of dipoles in each ring quasi-array is assumed to be infinitely large; this simplifying assumption should not cause any appreciable deviation from the actual conditions.

The special case of a ring quasi-array of tangential dipoles with constant current phase, i.e. $H=0$, has been dealt with in detail by Foster,[2] who applies the Poynting vector method, and by Moullin,[3] who applies the emf method. The results reached by these authors are contained as special cases in the present investigation.

The radiation resistance and the gain in the case of an arbitrary value of H will be derived here on the basis of the Poynting vector method. The calculations follow a line similar to that of Foster[2] in his calculations for the special case $H=0$. However, Foster's method has to be modified and extended in order that it may be applicable here. To some extent Page's[4] calculation of the radiation resistance and gain of a homogeneous ring array of axial dipoles has also been guiding in the following calculations.

TANGENTIAL DIPOLES

Calculation of Radiation Resistance and Gain

In this section we shall calculate the radiation resistance and the gain of a homogeneous ring quasi-array of an infinite number of dipoles placed along a circle with radius a so that the dipoles are tangent to this circle, as shown in Fig. 1(b). We first formulate the problem of the corresponding ring quasi-array with a finite number, s, of elements, each one having the length L, see Fig. 1(a). As shown in this figure, we introduce a spherical co-ordinate system (r, θ, ϕ). In this system the j'th dipole has the co-ordinates

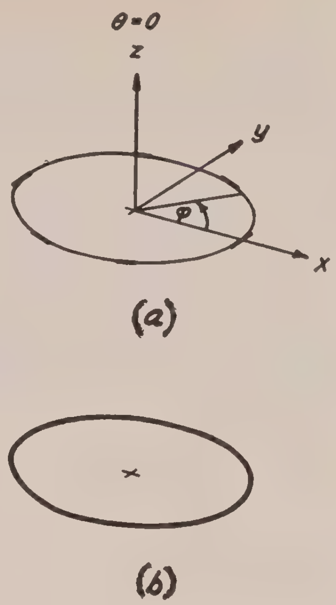


Fig. 1—Ring quasi-array of: (a) a finite number of tangential dipoles, and (b) infinitely many tangential dipoles.

$$(r, \theta, \phi)_{j'\text{th dipole}} = \left(a, \frac{\pi}{2}, u_j\right) \tag{1}$$

where

$$u_j = \frac{2\pi j}{s}, \qquad j = 1, 2, \cdots, s. \tag{2}$$

The current I_j in the j'th dipole is given by

$$I_j = Ie^{iHu_j}, \tag{3}$$

where I is complex constant and H integral number.

We now let the number of elements, s, increase beyond all limits and the length of each dipole, L, decrease in such a way that the product sL remains finite. As shown in a previous paper,[1] the components of the electric field strength in the far zone field of the quasi-array are then expressed by

$$\overline{E} = T\overline{F}, \tag{4}$$

where

$$T = \frac{iksL\zeta I}{4\pi r} e^{ikr} \tag{5}$$

and

$$F_\theta = \frac{H}{z} J_H(z) \cos\theta e^{iH(\phi-\pi/2)}, \tag{6a}$$

$$F_\phi = iJ_H'(z) e^{iH(\phi-\pi/2)}, \tag{6b}$$

$$z = ka \sin\theta. \tag{7}$$

In this expression $k=\omega\sqrt{\mu\epsilon}$ denotes the intrinsic propagation constant and $\zeta=\sqrt{\mu/\epsilon}$ the intrinsic impedance of space. As an example we have plotted in Fig. 2 the radiation pattern of a quasi-array with $a/\lambda=0.6$ and $H=4$.

---

[2] D. Foster, "Loop antennas with uniform current," PROC. I.R.E., vol. 32, pp. 603–607; October, 1944.

[3] E. B. Moullin, "Radiation from large circular loops," *Jour. IEE*, part III, vol. 93, pp. 345–351; 1946.

[4] H. Page, "Radiation resistance of ring aerials," *Wireless Eng.*, vol. 25, pp. 102–109; April, 1948.

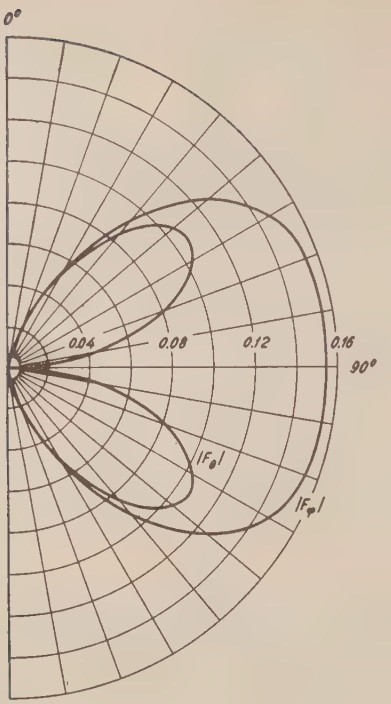


Fig. 2—Field θ- and ϕ-components, radiated by a homogeneous ring quasi-array of tangential dipoles, with $\alpha/\lambda=0.6$ and $H=4$.

We now find the total radiated effect P_H by integrating radial component of Poynting vector $\overline{S}=\frac{1}{2}\overline{E}\times\tilde{\overline{H}}$ over a large spherical surface with radius r and with its center at the antenna system. Hereby we obtain

$$\begin{aligned} P_H &= 2\pi\int_0^\pi S_r r^2 \sin\theta d\theta \\ &= 2\pi\int_0^\pi \frac{r^2}{2\zeta}\overline{E}\cdot\tilde{\overline{E}}\sin\theta d\theta = \frac{(ksL)^2\zeta I\tilde{I}}{8\pi}M_H \qquad (8)\end{aligned}$$

where

$$M_H(ka) = \frac{1}{2}\int_0^\pi m_H(ka,\theta)\sin\theta d\theta \qquad (9)$$

with

$$\begin{aligned} m_H(ka,\theta) &= F_\theta\tilde{F}_\theta + F_\phi\tilde{F}_\phi \\ &= \left(\frac{H}{z}J_H(z)\cos\theta\right)^2 + (J_H'(z))^2. \qquad (10)\end{aligned}$$

In these and the following formulas $\tilde{a}$ denotes the complex conjugate of a.

Defining the radiation resistance R_H in relation to the current I in one of the dipoles by

$$P_H = \tfrac{1}{2}R_H I\tilde{I}, \qquad (11)$$

we finally find

$$R_H = ZM_H(ka), \qquad (12)$$

where

$$Z = \frac{(ksL)^2}{4\pi}\zeta. \qquad (13)$$

The directive properties of an antenna is expressed by its gain. The gain $g_H(\theta)$ of an azimuthally omnidirectional antenna in the direction (θ, ϕ) is defined by

$$g_H(\theta) = \frac{S(\theta)}{S_{\text{mean}}}. \qquad (14)$$

As

$$S_{\text{mean}} = \frac{P_H}{4\pi r^2}, \qquad (15)$$

we find for the quasi-array considered here

$$g_H(\theta) = \frac{m_H(ka,\theta)}{M_H(ka)}, \qquad (16)$$

where $m_H(ka,\theta)$ and $M_H(ka)$ are expressed by (10) and (9), respectively.

The problem of calculating the radiation resistance as well as that of calculating the gain have thus been reduced to the question of obtaining an expression for the definite integral $M_H(ka)$. We have to investigate separately the cases $H=0$ and $|H|\geqq 1$.

$H=0$: The definite integral $M_0(ka)$ has been evaluated by Foster.[2] He arrives at the result

$$M_0(ka) = \frac{1}{2ka}\bar{J}_2(2ka), \qquad (17)$$

where we have introduced the notation

$$\bar{J}_n(x) = \int_0^x J_n(t)dt, \qquad (18)$$

a notation which is used by several authors, though not by Foster.

The function $\bar{J}_n(x)$ has been tabulated for $n=0$, amongst others by Lowan and Abramowitz,[5] who have published a table of $\bar{J}_0(x)$, 10 d, $x=0(0.01)10$. However, no table of $\bar{J}_n(x)$ seems to have been published for $n\geqq 1$, although these functions have found application also in the solution of other technical problems than the one considered here, e.g. in the calculation of transient phenomena in electric wave filters.[6] The author has prepared a table of $\bar{J}_n(x)$, $5d$, $n=1(1)8$, $x=0(0.02)10$, which is included in a recently published monograph.[7] In Appendix I to the present paper the calculation of $\bar{J}_n(x)$ is briefly outlined, and curves of these functions are given.

By using the above mentioned table or the curves in Appendix I we may now calculate the definite integral $M_0(ka)$ as expressed by (17). The function $M_0(x)$ is plotted in Fig. 3 for $0\leqq x\leqq 5$.

---

[5] A. N. Lowan and M. Abramowitz, "Table of the integrals $\int_0^x J_0(t)dt$ and $\int_0^x Y_0(t)dt$," *Jour. Math. Phys.*, vol. 22, pp. 2–12; 1943.

[6] J. Rybner, "Om Heavisides Operatorregning," ("On Heaviside's operational calculus"), *Ingeniøren* (Copenhagen), part E, vol. 49, pp. 93–103; 1940.

[7] H. L. Knudsen, "Bidrag til teorien for antennesystemer med hel eller delvis rotationssymmetri," (contribution to the theory of antenna systems with complete or in part rotational symmetry). *I kommission hos Teknisk Forlag*, Copenhagen, Denmark; 1953.

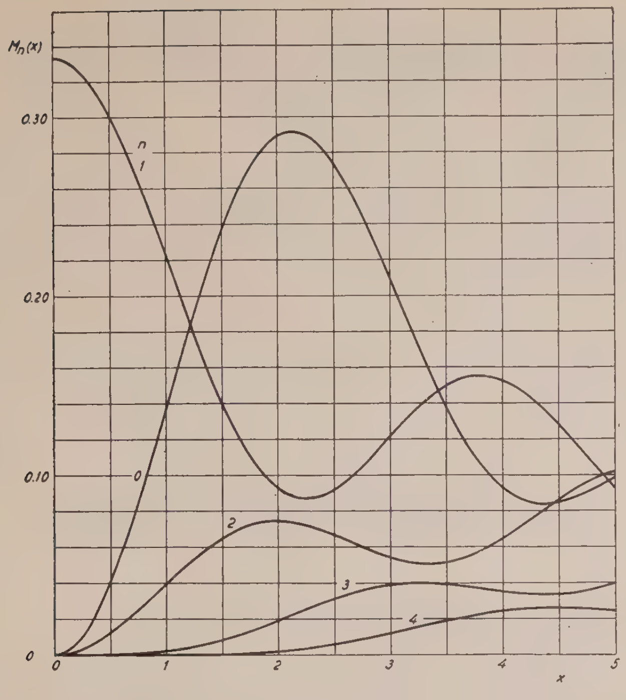


Fig. 3—The function $M_n(x)$ defined in (19) for a ring quasi-array of tangential dipoles.

$|H| \geqq 1$: Having treated the case of $H=0$ we now assume that $|H| \geqq 1$. The radiation resistance and the gain being the same for H and for $-H$, we need in this section only consider the positive values of H, i.e. we may assume that $H \geqq 1$. By inserting the expression (10) for m_H in the expression (9) for M_H, applying Bessel's recursion formulas, and transforming further, we obtain

$$\begin{aligned} M_H(ka) &= \frac{1}{8}\int_0^\pi \left[(J_{H-1}(z) + J_{H+1}(z))^2 \cos^2\theta \right. \\ &\qquad \left. + (J_{H-1}(z) - J_{H+1}(z))^2\right] \sin\theta d\theta \\ &= \frac{1}{8}\int_0^\pi \left[(J^2{}_{H-1}(z) + J^2{}_{H+1}(z))(1+\cos^2\theta) \right. \\ &\qquad \left. - 2J_{H-1}(z)J_{H+1}(z)\sin^2\theta\right] \sin\theta d\theta \\ &= \frac{1}{8}\left[A_{H-1}(ka) + A_{H+1}(ka) - 2B_H(ka)\right], \end{aligned} \tag{19}$$

where

$$A_n(x) = \int_0^\pi J_n{}^2(x\sin\theta)(2-\sin^2\theta)\sin\theta d\theta, \tag{20}$$

$$B_n(x) = \int_0^\pi J_{n-1}(x\sin\theta)J_{n+1}(x\sin\theta)\sin^3\theta d\theta. \tag{21}$$

The problem has now been reduced to the question of calculating the functions $A_n(x)$ and $B_n(x)$. In Appendix II it is shown that $A_n(x)$ and $B_n(x)$ may be expressed as follows

$$\begin{aligned} A_n(x) &= \left[\frac{3}{2x} - \frac{4n^2-1}{8x^3}\right]\bar{J}_{2n}(2x) \\ &\quad + \frac{2n-1}{4x^2}J_{2n}(2x) - \frac{1}{2x}J_{2n+1}(2x), \end{aligned} \tag{22}$$

$$\begin{aligned} B_n(x) &= \left[-\frac{1}{2x} + \frac{3(4n^2-1)}{8x^3}\right]\bar{J}_{2n}(2x) \\ &\quad - \frac{3(2n-1)}{4x^2}J_{2n}(2x) + \frac{3}{2x}J_{2n+1}(2x). \end{aligned} \tag{23}$$

The functions $A_n(x)$ and $B_n(x)$, and consequently also the definite integral M_H, are now expressed through known functions, including the function $\bar{J}_n(x)$, which was defined in (18) and plotted in Appendix I.

The function $A_n(x)$ is plotted in Figs. 14 and 15. On the basis of these curves the function $M_n(x)$ has been calculated and plotted in Fig. 3 for $0 \leqq x \leqq 5$ and for $n=1, 2, 3$, and 4.

Discussion of the result

We have now obtained expressions for the definite integral $M_H(ka)$ for any value of H. By inserting these expressions for $M_H(ka)$ in (12) we may now calculate the radiation resistance R_H. In Fig. 4 $(2\pi a/sL)^2 R_H$ is plotted as a function of a/λ for $|H|=0$, 1, 2, 3, and 4. The radiation resistance corresponding to $H=0$ has been plotted in Foster's[2] as well as in Moullin's[3] papers previously referred to. It seems that an error has slipped into Moullin's calculation of the radiation resistance for $H=0$; as far as I can figure out, the radiation resistance is twice the magnitude given by the curve in Fig. 3 of Moullin's paper. The curves in Fig. 4 show that the radiation resistance for an arbitrary value of H increases, though not monotonously, with increasing radius of the circle. For a constant radius the radiation

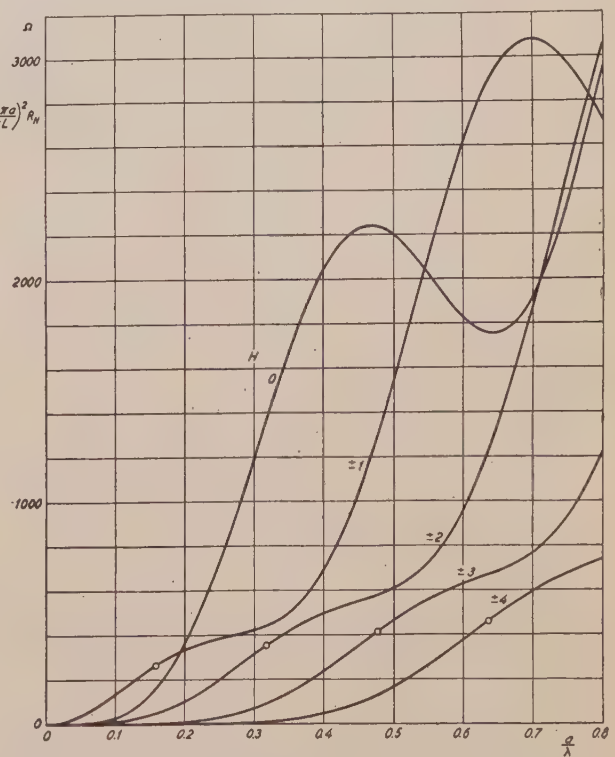


Fig. 4—The radiation resistance R_H multiplied by $(2\pi a/sL)^2$ of a homogeneous ring quasi-array of tangential dipoles.

resistance is seen to decrease with increasing $|H|$; when $|H|$ becomes sufficiently large, super-gain occurs, and the quasi-array becomes practically inapplicable, as was discussed in a former paper.[8]

By inserting the obtained expressions for $m_H(ka, \theta)$ and $M_H(ka)$ in (16) the gain $g(\theta)$ of the quasi-array may be found. The gain in horizontal directions, $\theta = \pi/2$, is plotted in Fig. 5 as a function of a/λ for $|H| = 0, 1, 2, 3,$ and 4. The curve corresponding to $H = 0$ is plotted also in the above mentioned papers by Foster[2] and Moullin[3] gives for $H = 0$ a curve showing the gain in the direction in which the gain assumes its largest value. For small values of the radius Foster's curve is identical with the curve in Fig. 5 that corresponds to $H = 0$. Fig. 5 shows that the gain in horizontal directions for any value of H first decreases monotonously towards zero and then oscillates. For $|H| \geqq 1$ and for small values of the radius the gain is seen to increase with increasing values of $|H|$. However, it is interesting to observe that for $|H| = 1$ as well as for $|H| = 2$, the gain—for small values of the radius—is smaller than the gain for $H = 0$. Not until for $|H| = 3$ the gain is larger than for $H = 0$. As a consequence of the increase of the gain with increasing $|H|$ the homogeneous ring quasi-array of tangential dipoles should be useful as an azimuthally omnidirectional antenna system with a mainly horizontally polarized field concentrated around the horizontal plane.

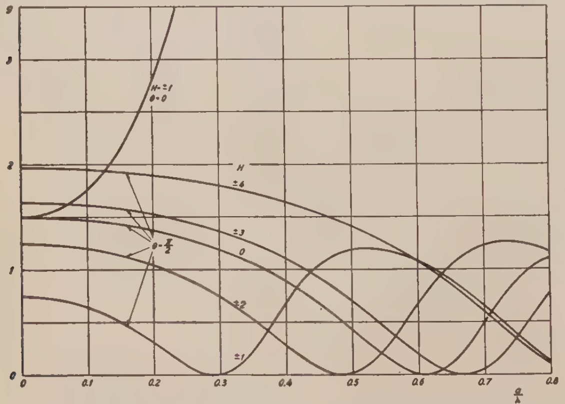


Fig. 5—The gain g_H in horizontal directions of a homogeneous ring quasi-array of tangential dipoles. The figure also shows the gain in the vertical direction of a quasi-array of this type with $|H| = 1$.

In Fig. 5 has been plotted for $|H| = 1$, also the gain in the axial directions $\theta = 0$ and π as a function of a/λ. This is shown better in Fig. 6. For other values of H the gain in these directions is zero. Whereas the gain in horizontal directions for the values of H and a/λ occurring in Fig. 5 was smaller than 2, the gain in the direction of the axis in the case of $|H| = 1$ assumes much larger values. Its first maximum occurs for $a/\lambda = 0.360$; the gain is then 5.75. As a consequence of its large gain in the axial directions a ring quasi-array of tangential dipoles with $|H| = 1$ should be useful as a bilaterally radiating beam antenna system with circular polarization in the directions of the principal lobes.

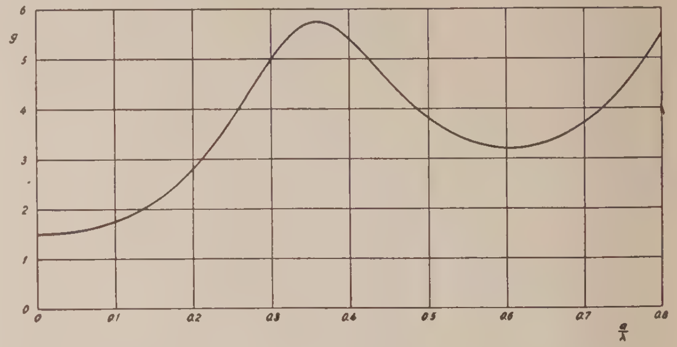
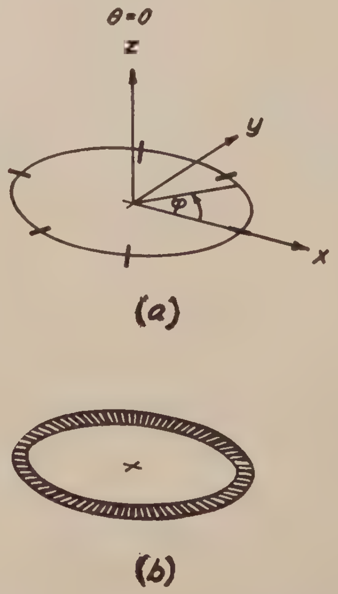


Fig. 6—The gain g_1 in the vertical direction of a homogeneous ring quasi-array of tangential dipoles with $|H| = 1$.

RADIAL DIPOLES

Calculation of Radiation Resistance and Gain

In this section we shall carry out a similar calculation of the radiation resistance and the gain of a homogeneous ring quasi-array of an infinite number of dipoles placed along a circle with radius a and oriented in radial directions, as shown in Fig. 7(b). We first formulate the problem of the corresponding ring quasi-array with a finite number, s, of elements, each one having the length L, see Fig. 7(a). In a spherical co-ordinate system (r, θ, ϕ), as shown in the figure, the position of the j'th dipole may be expressed by (1) and (2), and the current in the j'th dipole by (3).



(a)

(b)

Fig. 7—Ring quasi-array of: (a) a finite number of radial dipoles, and (b) infinitely many radial dipoles.

We let now the number of elements, s, increase towards infinity and the length of each dipole, L, decrease towards zero in such a way that sL remains finite. As was shown in a previous paper[1] the electric field strength in the far zone may then be expressed by (4) and (5), where

---

[8] H. L. Knudsen, "Superforstærkning hos antenner" ("Super-gain of antennas"). *Elektroteknisk Tidsskrift* (Oslo, Norway), vol. 64, pp. 213–221; 1951.

$$F_\theta = iJ_H'(z)\cos\theta e^{iH(\phi-\pi/2)}, \tag{24a}$$

$$F_\phi = -\frac{H}{z} J_H(z) e^{iH(\phi-\pi/2)}, \tag{24b}$$

where z is given by (7). As an example the radiation pattern of a quasi-array with $a/\lambda = 0.6$ and $H = 4$ is plotted in Fig. 8.

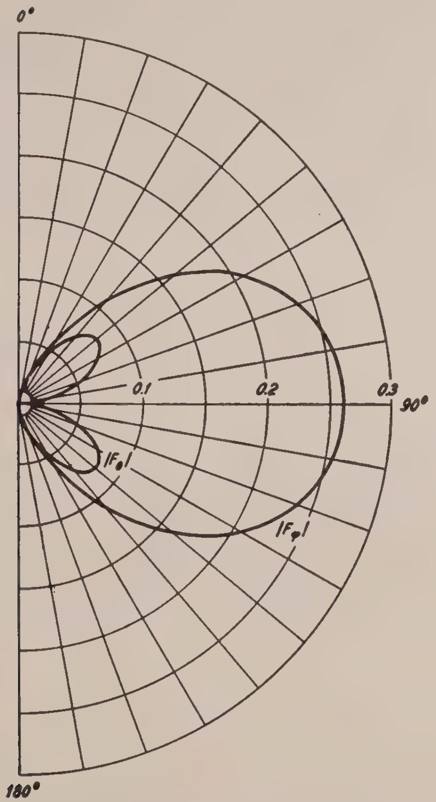


Fig. 8—The θ- and ϕ-components of the field radiated by a homogeneous ring quasi-array of radial dipoles with $a/\lambda = 0.6$ and $H = 4$.

As in the previous section we may express the radiation resistance R_H of the quasi-array in relation to the current I in one of the dipoles by (12) and (13), where in the present case

$$M_H(ka) = \frac{1}{2}\int_0^\pi m_H(ka, \theta)\sin\theta d\theta \tag{25}$$

with $m_H(ka, \theta)$ defined in accordance with (10)

$$m_H(ka, \theta) = F_\theta \tilde{F}_\theta + F_\phi \tilde{F}_\phi$$
$$= (J_H'(z)\cos\theta)^2 + \left(\frac{H}{z} J_H(z)\right)^2. \tag{26}$$

The gain $g(\theta)$ of the quasi-array considered here is expressed by (16), where $m_H(ka, \theta)$ and $M_H(ka)$ are given by (26) and (25).

We have to investigate the cases $H = 0$ and $|H| \geqq 1$ separately.

$H = 0$: For $H = 0$ we find from (26)

$$m_0(ka, \theta) = J_1^2(z)\cos^2\theta, \tag{27}$$

and by substituting this expression in (25) we obtain

$$M_0(ka) = \frac{1}{2}\int_0^\pi J_1^2(ka\sin\theta)\cos^2\theta\sin\theta d\theta. \tag{28}$$

As shown in Appendix III this integral may be expressed by

$$M_0(ka) = \frac{1}{8}[A_1(ka) - B_1(ka)], \tag{29}$$

where $A_n(x)$ and $B_n(x)$ are previously defined functions, expressed in (22) and (23) by tabulated functions for an arbitrary integer index n. The function $M_0(x)$ is plotted in Fig. 9 for $0 \leqq x \leqq 5$.

$|H| \geqq 1$: As the radiation resistance and the gain assume the same values for H as for $-H$, it is sufficient to carry out the calculation for $H \geqq 1$. For this range of H we transform the expression (26) for $m_H(ka, \theta)$ by using Bessel's recursion formulas; substituting the result in (25) we obtain

$$M_H(ka) = \frac{1}{8}\int_0^\pi [(J_{H-1}(ka) - J_{H+1}(ka))^2\cos^2\theta$$
$$+ (J_{H-1}(z) + J_{H+1}(z))^2]\sin\theta d\theta. \tag{30}$$

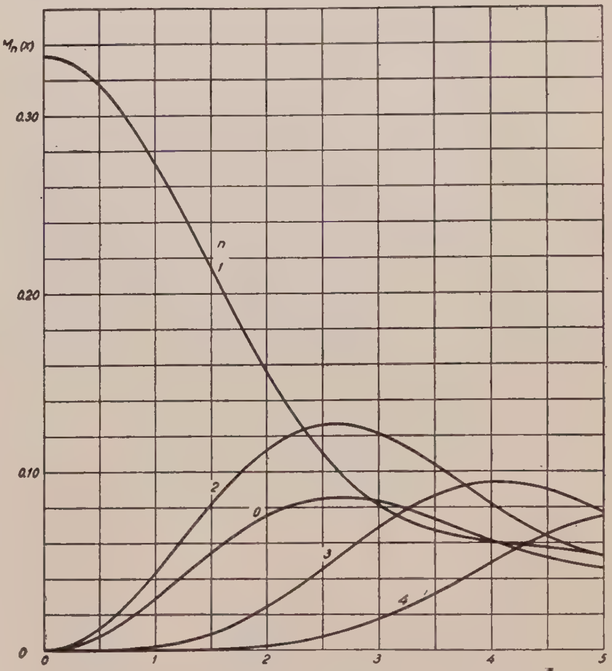


Fig. 9—The function $M_n(x)$ defined in (30) for a ring quasi-array of radial dipoles.

Applying the functions $A_n(x)$ and $B_n(x)$ defined in (22) and (23) we may transform this expression into

$$M_H(ka) = \frac{1}{8}[A_{H-1}(ka) + A_{H+1}(ka) + 2B_H(ka)]. \tag{31}$$

On the basis of the curves of $A_n(x)$ and $B_n(x)$ plotted in Appendix II the auxiliary function $M_n(x)$ is calculated and plotted in Fig. 9 for $0 \leqq x \leqq 5$ and for $n = 0, 1, 2, 3,$ and 4.

Discussion of the Result

Substituting the above developed expressions for $M_n(ka)$ in (12) we find the radiation resistance R_H for the ring quasi-array considered here with the current in an arbitrary dipole as reference current. In Fig. 10 $(2\pi a/sL)^2 R_H$ is plotted as a function of a/λ for $|H|=0$, 1, 2, 3, and 4. This figure shows that the radiation resistance increases, though not monotonously, with increasing radius of the circle. Excepting the case $H=0$ we see that for a small radius of the circle the radiation resistance decreases with increasing $|H|$. Comparing the result arrived at here with the radiation resistance for a corresponding ring quasi-array of tangential dipoles, plotted in Fig. 4, we observe that the radiation resistances for two quasi-arrays with the same radius and with the same $|H|$, but with respectively tangential and radial dipoles, may be very different.

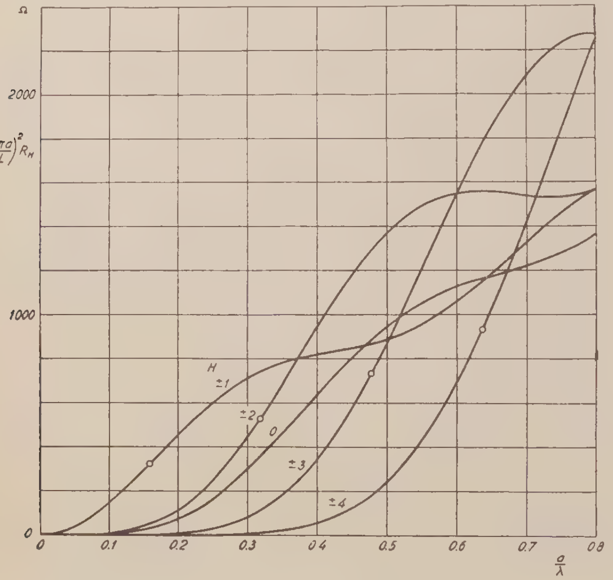


Fig. 10—The radiation resistance R_H multiplied by $(2\pi a/sL)^2$ of a homogeneous ring quasi-array of radial dipoles.

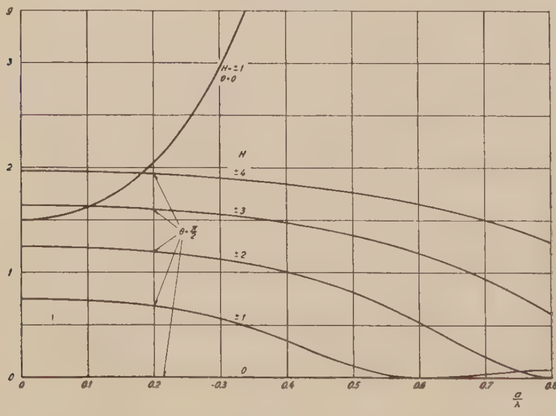


Fig. 11—The gain g_H in horizontal directions of a homogeneous ring quasi-array of radial dipoles. The figure also shows the gain in the vertical direction of a quasi-array of this type with $|H|=1$.

The gain of the quasi-array, $g_H(\theta)$, is calculated by substituting in (14) the expressions (26), (29) and (31) for $m_H(ka, \theta)$ and $M_H(ka)$. In Fig. 11 the gain in horizontal directions $\theta=\pi/2$ is plotted as a function of a/λ for $|H|=1$, 2, 3, and 4. For $H=0$ the gain in horizontal directions is zero. For $|H|=1$ the gain in the directions of the axis, $\theta=0$ and π, is plotted in Fig. 11 and better in Fig. 12. For other values of H the gain in these directions is zero. The curves of the gain in horizontal directions have the same character as the corresponding curves in the case of tangential dipoles given in Fig. 5; but the present curves decrease more slowly towards the first zero than those in Fig. 5. A homogeneous ring quasi-array of radial dipoles and with $|H| \geqq 2$ seems therefore more fit for obtaining simultaneously a large gain and a large radiation resistance than a corresponding quasi-array of tangential dipoles. In the interval of a/λ, for which the gain is plotted here, the gain in the direction of the axis assumes much larger values for radial than for tangential dipoles, as is seen by comparing Figs. 6 and 12.

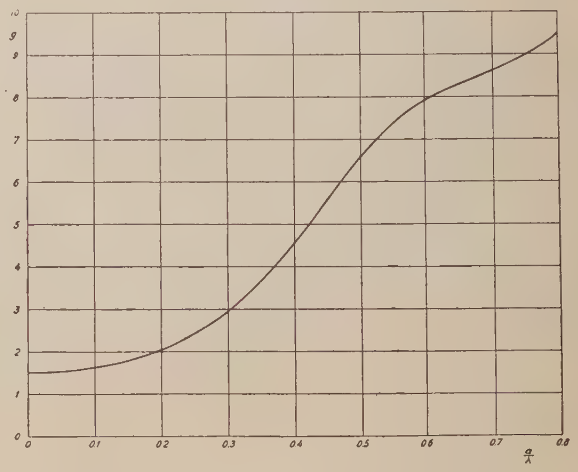


Fig. 12—The gain g_1 in the vertical direction of a homogeneous ring quasi-array of radial dipoles with $|H|=1$.

APPENDIX I

Calculation of $\bar{J}_n(x)$

It seems that only few tables of the function

$$\bar{J}_n(x) = \int_0^x J_n(t)dt \tag{32}$$

have been published. Apart from isolated values it has not been possible for the author to find any table of $\bar{J}_n(x)$ for other values of n than $n=0$.

In his monograph on the Bessel functions Watson[9] gives a table of $\frac{1}{2}\bar{J}_0(x)$, $7d$, $x=0(0.02)1$. A similar table, but calculated to four decimal places only, has been published by Glazenap.[10]

The most comprehensive table of $\bar{J}_0(x)$ published so far seems to be a table calculated by Lowan and Abramowitz[5]; this table is characterized by $10d$, $x=0(0.02)10$.

---

[9] G. N. Watson, "A treatise on the theory of Bessel functions," Cambridge England, 2nd ed., p. 752; 1944.

[10] S. P. Glazenap, "Matematicheskie i Astronomicheskie Tablitsy," Leningrad, Russia, pp. 91–115; 1932.

The reason why no table of $\bar{J}_n(x)$ for other values of n than $n=0$ has been published is probably that for $n \geqq 1$ the function $\bar{J}_n(x)$ may be expressed through Bessel functions and—in the case of even n—the function $\bar{J}_0(x)$. As it may be convenient to have a table of tgx, though tables of cos$x$ and sin$x$ are available, it will to a still higher degree be convenient to dispose of a table of $\bar{J}_n(x)$ for $n \geqq 1$, though $\bar{J}_n(x)$ may be expressed by tabulated functions.

To obtain a formula that expresses $\bar{J}_n(x)$ through tabulated functions we integrate Bessel's recursion formula expressed as follows

$$J_n(x) = J_{n-2}(x) - 2J'_{n-1}(x). \tag{33}$$

Hereby we find for $n \geqq 2$

$$\bar{J}_n(x) = \bar{J}_{n-2}(x) - 2J_{n-1}(x). \tag{34}$$

As

$$\bar{J}_1(x) = 1 - J_0(x), \tag{35}$$

we find from this recursion formula

$$\bar{J}_n(x) = \begin{cases} 1 - J_0(x) - 2 \sum\limits_{j=1}^{(n-1)/2} J_{2j}(x) \quad \text{for } n \text{ odd}, & (36\text{a}) \\ \bar{J}_0(x) - 2 \sum\limits_{j=1}^{n/2} J_{2j-1}(x) \quad \text{for } n \text{ even}. & (36\text{b}) \end{cases}$$

Instead of the formulas given above we may use the following infinite series[11]

$$\bar{J}_n(x) = 2 \sum_{j=0}^{\infty} J_{n+2j+1}(x). \tag{37}$$

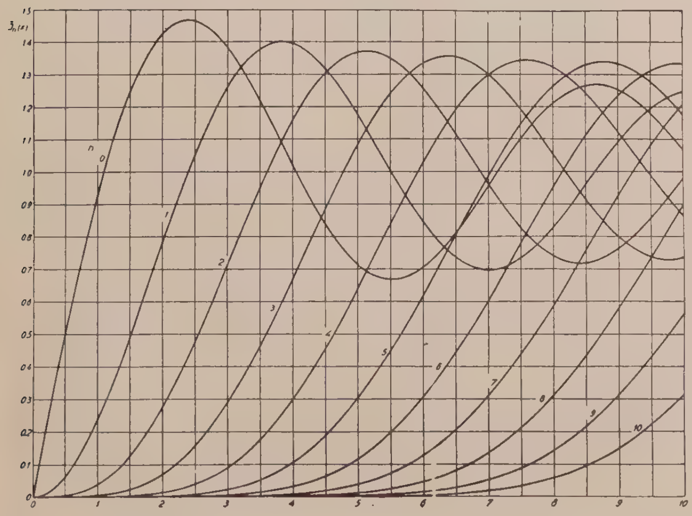


Fig. 13—The function $\bar{J}_n(x) = \int_0^x J_n(t)dt$.

As a Bessel function of a constant argument decreases rapidly towards zero with increasing order, this series converges rapidly for $n > x$.

By applying the formulas (36a and b) and by using the tables of the Bessel functions by the Harvard Computation Laboratory[12] as well as Lowan and Abramowitz's table of $\bar{J}_0(x)$,[5] a table has been prepared of $\bar{J}_n(x)$ for $n=1, 2, 3, \cdots, 8$ and with $5d$, $x=0(0.02)10$.[7] There is an inaccuracy of one on the last decimal place of the figures in this table. The function $\bar{J}_n(x)$ is plotted in Fig. 13 as a function of x for $n=0, 1, 2, \cdots, 8$ and $0 \leqq x \leqq 10$.

APPENDIX II

Calculation of the Definite Integrals $A_n(x)$ and $B_n(x)$

We shall here express the definite integrals $A_n(x)$ and $B_n(x)$, defined in (20) and (21), by known functions, assuming that $n \geqq 0$.

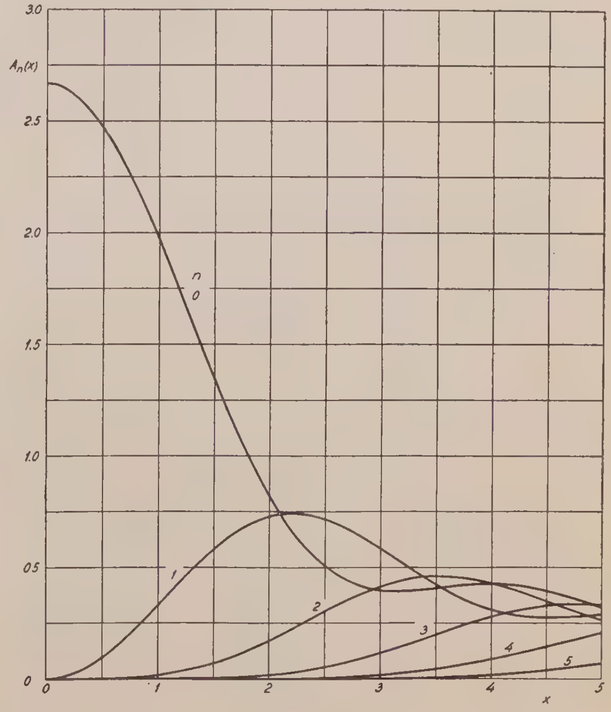


Fig. 14—The function $A_n(x) = \int_0^\pi J_n^2(x \sin\theta)(2-\sin^2\theta)\sin\theta\, d\theta$.

For the purpose of transforming the expression for $A_n(x)$ we use Schläfli's series expansion of the product of two Bessel functions[13]

$$J_\mu(x)J_\nu(x) = \sum_{m=0}^{\infty} \frac{(-1)^m \left(\frac{x}{2}\right)^{2m+\mu+\nu} \Gamma(2m+\mu+\nu+1)}{m!\Gamma(m+\mu+\nu+1)\Gamma(m+\mu+1)\Gamma(m+\nu+1)} \cdot \tag{38}$$

Setting $\mu=\nu=n$ in this equation and inserting the resulting expression in (20), we find

$$A_n(x) = \sum_{n=0}^{\infty} \frac{(-1)^m \left(\frac{x}{2}\right)^{2m+2n} \Gamma(2m+2n+1)}{m!\Gamma(m+2n+1)\Gamma^2(m+n+1)} \cdot \int_0^\pi (2-\sin^2\theta)(\sin\theta)^{2m+2n+1} d\theta. \tag{39}$$

---

[11] E. Jahnke and F. Emde, "Funktionentafeln," Leipzig and Berlin, Germany, 3rd ed., p. 145; 1938.

[12] "Tables of the Bessel functions of the first kind," Annals of the Computation Laboratory of Harvard University; 1947.

[13] G. N. Watson, op. cit., p. 147.

We may transform the integrals in the terms of this series expression by using Euler's formula[14]

$$\int_0^{\pi/2} \cos^{m-1} x \sin^{n-1} x dx = \frac{1}{2} \frac{\Gamma\left(\frac{m}{2}\right)\Gamma\left(\frac{n}{2}\right)}{\Gamma\left(\frac{m+n}{2}\right)}. \qquad (40)$$

Setting in this equation $m-1=n-1=p$, we obtain

$$\begin{aligned} 2^{p+1}\int_0^{\pi/2} \cos^p x \sin^p x dx &= \int_0^{\pi/2} \sin^p 2x d(2x) \\ &= \int_0^{\pi} \sin^p y dy \\ &= 2^p \frac{\Gamma^2\left(\frac{p+1}{2}\right)}{\Gamma(p+1)}. \end{aligned} \qquad (41)$$

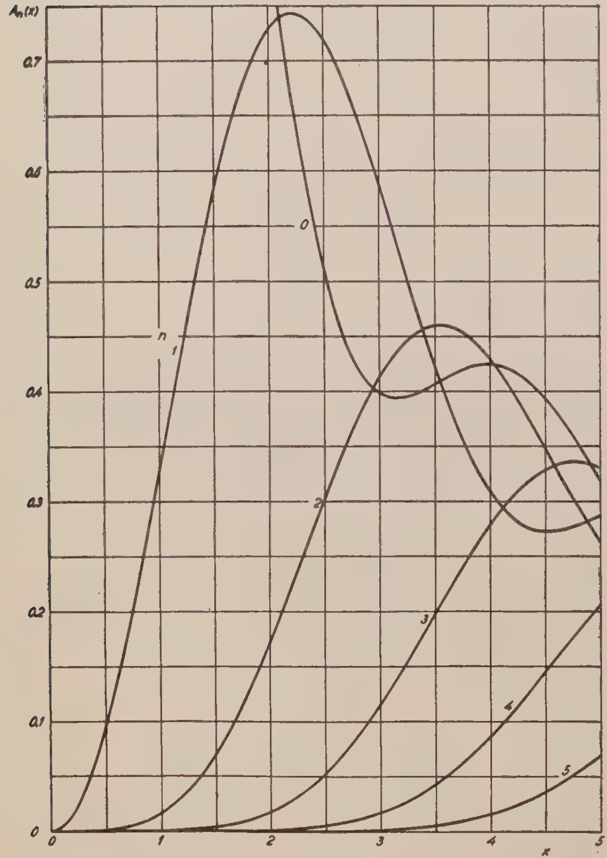


Fig. 15—The function $A_n(x)=\int_0^\pi J_n^2(x \sin \theta)(2-\sin^2 \theta) \sin \theta \, d\theta$. This figure shows in greater detail a part of Fig. 14.

By using this integral we may transform the integral occurring in the series (39) for $A_n(x)$

$$\begin{aligned} \int_0^{\pi} (2-\sin^2\theta)(\sin\theta)^{2m+2n+1}d\theta &= 2^{2m+2n+2}\frac{\Gamma^2(m+n+1)}{\Gamma(2m+2n+2)} \\ &\quad - 2^{2m+2n+3}\frac{\Gamma^2(m+n+2)}{\Gamma(2m+2n+4)} \\ &= 2^{2m+2n+2}\frac{\Gamma^2(m+n+1)(2m+2n+2)(m+n+2)}{\Gamma(2m+2n+4)}. \end{aligned} \qquad (42)$$

Inserting this expression in (39), we find

$$A_n(x) = \sum_{m=0}^{\infty} K_m x^{2m+2n} \frac{4(m+n+2)}{(2m+2n+1)(2m+2n+3)}, \qquad (43)$$

where, for the sake of brevity, we have introduced

$$K_m = \frac{(-1)^m}{m!\Gamma(m+2n+1)}. \qquad (44)$$

In transforming the expression for the function $B_n(x)$ defined in (21) we proceed in a similar way. In the series expansion (38) for the product of two Bessel functions we set $\mu=n-1$ and $\nu=n+1$. Substituting the resulting expression in (21), we find

$$B_n(x) = \sum_{m=0}^{\infty} \frac{(-1)^m \left(\frac{x}{2}\right)^{2m+2n} \Gamma(2m+2n+1)}{m!\Gamma(m+2n+1)\Gamma(m+n)\Gamma(m+n+2)} \cdot \int_0^{\pi} (\sin\theta)^{2m+2n+3}d\theta. \qquad (45)$$

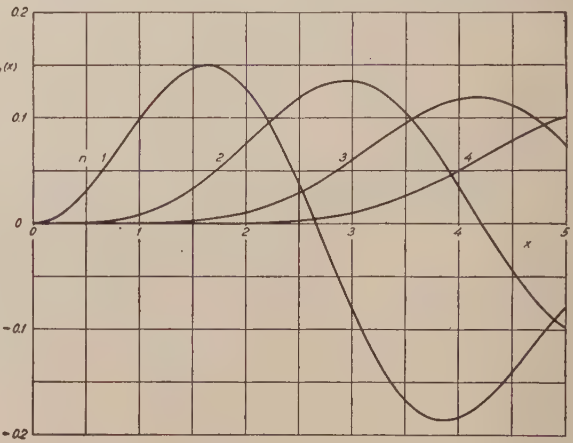


Fig. 16—The function $B_n(x)=\int_0^\pi J_{n-1}(x \sin \theta)J_{n+1}(x \sin \theta) \sin^3 \theta \, d\theta$.

We transform the integrals occurring in this series expansion by using the formula (41) in which we set $p=2m+2n+3$,

$$\int_0^{\pi} (\sin\theta)^{2m+2n+3}d\theta = 2^{2m+2n+3}\frac{\Gamma^2(m+n+2)}{\Gamma(2m+2n+4)}. \qquad (46)$$

Inserting this in (45) above for $B_n(x)$, we obtain

$$B_n(x) = \sum_{m=0}^{\infty} K_m x^{2m+2n} \frac{4(m+n)}{(2m+2n+1)(2m+2n+3)}, \qquad (47)$$

where K_m is the coefficient defined above in (44).

---

[14] E. T. Whittaker and G. N. Watson, "A course of modern analysis," Cambridge, England, 4th ed., p. 256; 1940.

The functions $A_n(x)$ and $B_n(x)$ may be expressed by the Bessel function of the order $2n$ and the argument $2x$, $J_{2n}(2x)$, and the integral of this function, $\overline{J}_{2n}(2x)$, where we have introduced the notation

$$\overline{J}_n(x) = \int_0^x J_n(t)dt. \tag{48}$$

The series expansion of the Bessel function $J_{2n}(2x)$ is given by

$$J_{2n}(2x) = \sum_{m=0}^{\infty} K_m x^{2m+2n}, \tag{49}$$

where K_m is the coefficient defined in (44). By inspection of the formulas for $A_n(x)$ and $B_n(x)$ we find that these functions may probably be expressed as a linear combination of the following four functions

$$\frac{1}{x}\overline{J}_{2n}(2x) = \sum_{m=0}^{\infty} K_m x^{2m+2n} \frac{2}{2m+2n+1}, \tag{50}$$

$$\frac{1}{x^3}\overline{J}_{2n}(2x) = \sum_{m=-1}^{\infty} K_m x^{2m+2n} \frac{-2}{(m+1)(m+2n+1)(2m+2n+3)}, \tag{51}$$

$$\frac{1}{x^2} J_{2n}(2x) = \sum_{m=-1}^{\infty} K_m x^{2m+2n} \frac{-1}{(m+1)(m+2n+1)}, \tag{52}$$

$$\frac{1}{x} J_{2n+1}(2x) = \sum_{m=0}^{\infty} K_m x^{2m+2n} \frac{1}{m+2n+1}. \tag{53}$$

We set tentatively

$$\left.\begin{matrix} A_n(x) \\ B_n(x) \end{matrix}\right\} = \left(\frac{a}{x} + \frac{b}{x^3}\right)\overline{J}_{2n}(2x) + \frac{c}{x^2} J_{2n}(2x) + \frac{d}{x} J_{2n+1}(2x). \tag{54}$$

As the terms corresponding to $m=1$ must disappear, the following relation must be satisfied

$$2b = -c[2m+2n+3]_{m=-1} = -c(2n+1). \tag{55}$$

Comparing the series expansions of both sides of (54) term by term, we find for the function $A_n(x)$

$$a = \frac{3}{2}, \qquad b = -\frac{4n^2-1}{8}, \qquad d = -\frac{1}{2}, \tag{56}$$

from which we obtain

$$A_n(x) = \left(\frac{3}{2x} - \frac{4n^2-1}{8x^3}\right)\overline{J}_{2n}(2x) + \frac{2n-1}{4x^2} J_{2n}(2x) - \frac{1}{2x} J_{2n+1}(2x). \tag{57}$$

For the function $B_n(x)$ we find by comparing both sides of (54) term by term

$$a = -\frac{1}{2}, \qquad b = \frac{3}{8}(4n^2-1), \qquad d = \frac{3}{2}, \tag{58}$$

from which we obtain

$$B_n(x) = \left(-\frac{1}{2x} + \frac{3(4n^2-1)}{8x^3}\right)\overline{J}_{2n}(2x) - \frac{3(2n-1)}{4x^2} J_{2n}(2x) + \frac{3}{2x} J_{2n+1}(2x). \tag{59}$$

APPENDIX III

Calculation of the Definite Integral $M_0(x)$ Defined for Radial Dipoles

In this section we shall express the function $M_0(x)$ defined for radial dipoles in (28). For the square of the Bessel function in this formula we substitute the series expansion (38) for the product of two Bessel functions in which we set $\nu=\mu=1$. Hereby we obtain

$$M_0(x) = \frac{1}{2}\sum_{m=0}^{\infty} \frac{(-1)^m \left(\frac{x}{2}\right)^{2m+2} \Gamma(2m+3)}{m!\Gamma(m+3)\Gamma^2(m+2)} \cdot \int_0^{\pi} [(\sin\theta)^{2m+3} - (\sin\theta)^{2m+5}]d\theta. \tag{60}$$

By using (41) we find

$$\begin{aligned} \int_0^{\pi} &[(\sin\theta)^{2m+3} - (\sin\theta)^{2m+5}]d\theta \\ &= 2^{2m+3}\frac{\Gamma^2(m+2)}{\Gamma(2m+4)} - 2^{2m+5}\frac{\Gamma^2(m+3)}{\Gamma(2m+6)} \\ &= 2^{2m+4}\frac{\Gamma^2(m+2)(m+2)}{\Gamma(2m+6)}. \end{aligned} \tag{61}$$

Inserting this result in (60) we obtain

$$M_0(x) = \sum_{m=0}^{\infty} \frac{(-1)^m x^{2m+2}}{m!\Gamma(m+3)(2m+3)(2m+5)}. \tag{62}$$

By comparing this expression for $M_0(x)$ with the series expressions (43) and (47) for $A_n(x)$ and $B_n(x)$ we see that

$$M_0(x) = \frac{1}{8}[A_1(x) - B_1(x)]. \tag{63}$$

ACKNOWLEDGEMENT

The author wishes to express his thanks to the head of The Microwave Laboratory, Professor J. Oskar Nielsen, for his continual encouragement, and to Professor Jørgen Rybner for having suggested a simplified derivation of the formulas in Appendixes II and III. I am also indebted to Mr. Preben Gudmandsen for valuable criticism. The English translation was revised by Mr. Oscar Kasch, sworn translator and interpreter.

A Stable Voltage-Controlled Logarithmic Attenuator*

GAIL E. BOGGS†, MEMBER, IRE

Summary—**A voltage-controlled logarithmic attenuator is presented that may be stabilized by the use of dc degeneration and a suitable increase in loop gain. The stabilized attenuator may be designed as either a high- or low-impedance device. A design procedure is outlined for each case. A discussion of experimental results concludes the paper.**

INTRODUCTION

AN AMPLIFIER which has a logarithmic input-output law will permit the output to be calibrated linearly in decibels. As a result of this convenience, logarithmic amplifiers are particularly useful in laboratory instrumentation and field intensity recording equipment.

Many logarithmic systems have been used in the past; a few of these are the successive detection system[1,2] which uses a detector after each stage, the automatic gain control[3,4] type and the germanium diode attenuator.[5] Each of these arrangements suffers from calibration instability. This paper presents a logarithmic system which may be called a variable electronic-impedance attenuator. This attenuator may be stabilized by the use of dc degeneration and a suitable increase in loop gain, resulting in a stable attenuator which is less sensitive to changes in electrode voltages and tube aging. The attenuator may be designed as either a high or low input-impedance device. A design procedure is presented for both types. Experimental verification of the design procedure and the results of cascade-attenuator operation conclude the paper.

VARIABLE ELECTRONIC-IMPEDANCE ATTENUATOR

Connecting a triode as shown in Fig. 1, results in an attenuator which makes use of the property that the cathode impedance varies approximately inversely as the transconductance. The attenuator tube is initially biased close to cutoff and the bias variations are supplied in a manner similar to AGC. If the operating parameters are judiciously chosen, the output will be the logarithm of the input. Variable electronic-impedance attenuators may be cascaded to increase the range and can be broad-band or single-frequency devices. Using the variation in plate resistance of the tube as the nonlinear element results in a high-impedance attenuator of similar performance.

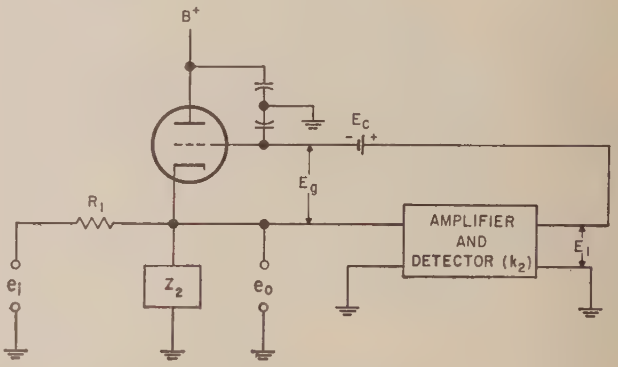


Fig. 1—Basic circuit of variable electronic-impedance attenuator.

In the analysis which follows, the nomenclature given below will be used:

C	Constant determined by attenuator voltages
E_c	Grid to cathode voltage with zero input voltage
E_g	Grid to cathode voltage
E_{in}	Grid to gound voltage
E_i	Maximum value of input voltage
E_o	Maximum value of output voltage
E_1	Dc output voltage of detector
g_m	Transconductance of attenuator tube
I_p	Average plate current of attenuator tube
k_1	Constant representing slope of attenuator characteristic
k_2	Amplifier gain with zero cathode resistance
k_3	Required amplifier gain with dc degeneration
K	Stability factor (k_3/k_2)
R_1	Series input resistance including source resistance
R_2	Effective resistance of cathode circuit impedance (Z_2) at f_0
R_3	Effective resistance of plate load at f_0
R_K	Dc cathode resistance
r_p	Variational plate resistance of attenuator tube
ω_0	Angular signal frequency.

For a logarithmic response characteristic over the operating range,

$$E_o = k_1 \log_{10} E_i + C. \tag{1}$$

In most cases E_i will be less than one volt, thus yielding a negative value for the logarithm. Writing the equation in the form shown allows direct substitution of the values of E_i.

The required form of the g_m curve as a function of E_i or E_o for a logarithmic characteristic is

---

* Decimal classification: R396.9. Original manuscript received by the Institute, November 10, 1952; revised manuscript received, November 20, 1953.

† National Bureau of Standards, Washington, D. C.

[1] S. N. Van Voorhis, "Microwave Receivers," Radiation Lab. Series, vol. 23, pp. 583–606, McGraw-Hill Book Co., Inc., New York, N. Y.; 1948.

[2] Joseph Croney, "A simple logarithmic receiver," PROC. I.R.E., vol. 39, pp. 807–813; July, 1951.

[3] S. Ballantine, "Variable tetrodes in logarithmic recording," *Electronics*, p. 472; January, 1931.

[4] H. A. Wheeler, "Automatic volume control for radio receiving sets," PROC. I.R.E., vol. 16, p. 30; January, 1928.

[5] W. N. Tuttle, U. S. Patent 2,104,336; January 4, 1938.

$$g_m = \frac{1}{R_1R_2}\left[\frac{R_2E_i}{k_1\log_{10}E_i + C} - R_1 - R_2\right]. \qquad (2)$$

If (2) is rewritten in terms of E_0 and a semi-logarithmic plot made for a typical case, the resultant curve will approach a straight line for large values of E_0. Thus it appears that a tube with an approximately logarithmic transfer characteristic is required in order to obtain the desired attenuator output.

For precision applications, it is highly desirable to have an attenuator whose response is independent of supply voltages, tube aging, etc. When dc stabilization is applied to a tube it has been shown[6] that the sensitivity of the transconductance to changes in input voltages is reduced by a factor of approximately $1+g_mR_K$.

The transconductance may be represented as

$$g_m = f(E_{in} + \sum E), \qquad (3)$$

where $\sum E$ is a voltage in series with E_{in} and represents to a first approximation, the effect of a change in perveance, Child's kernel or electrode voltages. Inserting a cathode resistance reduces the sensitivity of the transconductance to changes in all parameters. In order to permit control of the required transconductance range, the grid to ground voltage E_{in} is now increased by a factor K. The result is

$$g_m = f\left(\frac{KE_{in} + \sum E}{1 + g_mR_K}\right). \qquad (4)$$

Inspection of (4) shows that the effect of variations in $\sum E$ has been reduced by a constant K. Thus the sensitivity of the transconductance to all tube voltages except the input grid voltage has been reduced by a factor of K. We will define K as a stability factor. It is seen to be the factor by which k_2 must be increased in order to overcome the degeneration of the cathode resistor.

It is worthy of note that since (3) and (4) are not of the same form, any relation expressing the transfer characteristic will show a slight alteration of the curve shape, upon insertion of the cathode resistor. This characteristic of the stabilized attenuator will, in some cases, enable the design engineer to obtain a logarithmic characteristic with a tube whose published transfer characteristic is not a sufficiently close approximation to the required logarithmic relation. It appears that this property also limits the value of cathode resistance, since a substantial increase in R_K beyond the value at which a logarithmic response is obtained will cause the characteristic to deviate from a logarithmic input-output law. Fortunately, considerable latitude in cathode resistance is allowable since the resulting change in transfer characteristic frequently is a second-order effect.

With a large cathode resistance the grid-voltage equation is

$$E_g = E_1 + E_c - I_pR_K \quad \text{where} \quad E_1 = Kk_2E_o. \qquad (5)$$

The fixed bias E_c should be obtained from a low-impedance regulated source which may be placed in series with either the grid or cathode as preferred. For applications in which the high voltage supply to the unit is regulated, it may be convenient to dispense with the low-voltage supplies and obtain the attenuator bias from a bleeder arrangement.

In order to minimize insertion loss and maximize range the cathode impedance R_2 should be large compared to R_1. At radio frequencies it may be more desirable to resonate the cathode circuit, since the cathode-to-ground capacitance limits the magnitude of the cathode impedance.

For broad-band applications of the low-impedance attenuator, the cathode circuit should be designed for a high impedance but a low Q. Since fractional values of Q are readily obtained with this arrangement, bandwidths of 2 mc or more may be expected.

A detailed design procedure for the low-impedance attenuator is included in the Appendix.

High-Impedance Attenuator

Connecting the tube as shown in Fig. 2 results in a high-impedance attenuator. The operation of this attenuator is similar to that just described except that the attenuation is controlled by the variation of the tube plate resistance rather than the changes in cathode impedance. Dc stabilization is again used to improve the attenuator stability and the tube is initially biased close to cutoff as before.

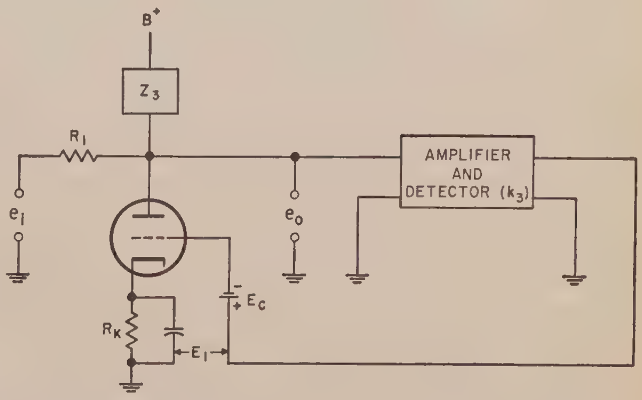


Fig. 2—Basic circuit of stabilized high-impedance attenuator.

The insertion loss is determined to a large extent by the plate-load impedance R_3. This impedance should be very high and in general will be a resonant circuit in order to reduce the dc voltage drop. A relatively narrow bandwidth will result with this circuit due to the higher Q. Since the bandwidth will change with attenuator level, this attenuator should be used only for applications requiring a smaller bandwidth than that of the low-impedance attenuator.

The required plate-resistance curve as a function of E_i is

---

[6] G. E. Valley, Jr. and H. Wallman, "Vacuum Tube Amplifiers," Radiation Lab. Series, vol. 18, pp. 357–359, McGraw-Hill Book Co., Inc., New York, N. Y.; 1948.

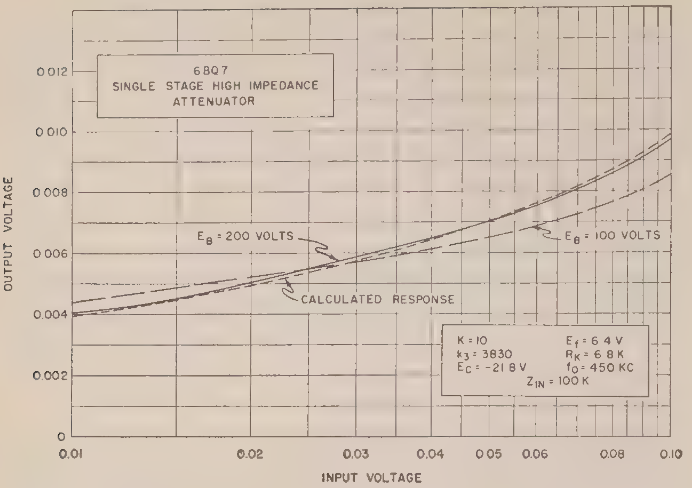


Fig. 3—Response of high-impedance attenuator with stabilization.

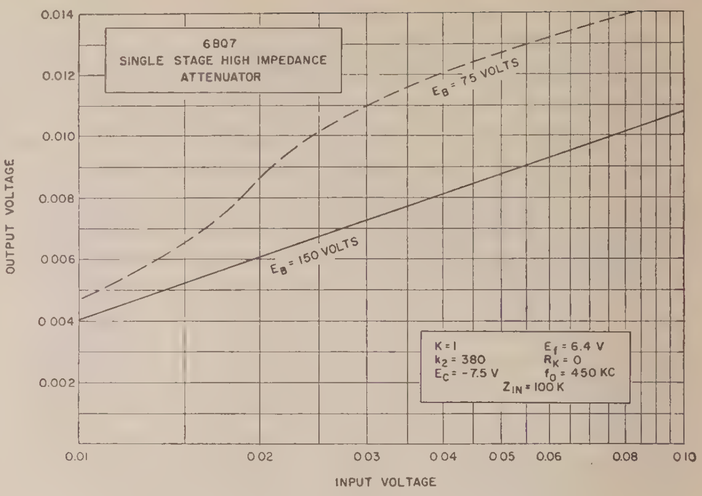


Fig. 4—Response of high-impedance attenuator without stabilization.

$$r_p = \frac{R_1R_3(k_1 \log_{10} E_i + C)}{R_3E_i - (R_1 + R_3)(k_1 \log_{10} E_i + C)}. \tag{6}$$

The expression for grid voltage is still given by (5).

A design procedure for the high-impedance attenuator is also given in the Appendix.

Experimental Results

The attenuation range may be extended by cascading two or more attenuators. The first stage of cascaded attenuators may be designed from the procedure outlined in the Appendix if the amplifier gain is increased by an amount equal to the insertion loss of the subsequent attenuators. The operating parameters of the second stage are generally the same as those for the first stage with the exception of the cathode resistor and the bias, which is usually beyond cutoff. In some cases, it will be necessary to operate the second stage with a lower value of cathode resistor than that used in the first stage in order to avoid driving the grid of the first tube positive at high levels. The second stage is biased so as to be inoperative over the operating range of the first tube. In practice, it is usually necessary to adjust the second-stage bias experimentally since attenuator characteristic must be blended as second tube becomes operative.

For precise instrumentation it is recommended that the amplifier used with this device be of the gain stable type. The amplifier must of course provide the required gain and accept the desired bandwidth.

As an example of design, consider a high-impedance, single-stage attenuator operating at 450 kc. A calculated response curve for this attenuator using a 6BQ7 tube is shown in Fig. 3. The input impedance is 100,000 ohms and a stability improvement (K) of 10 was specified. Fig. 3 also gives the experimental response obtained from this attenuator with a supply voltage of 200v as well as the response obtained when the supply voltage is reduced to 100v. The experimental characteristic is found to be in good agreement with the predicted response, the error being less than one db at any point in the design range. Operating the attenuator at reduced supply voltage results in a maximum deviation from the design-center curve of approximately 2 db.

When this attenuator is designed to operate without stability improvement ($K=1$), the results are as shown in Fig. 4. In this case, a lower plate supply voltage is used since there is no dc dathode voltage. Operating the attenuator at a plate-supply voltage of one-half the design-center value results in a maximum error of approximately 11 db. The inability to substantiate the stability criterion is probably due to approximations in the design and experimental error.

The unstabilized attenuator is seen to be logarithmic over the design range to within 0.1 db. In the stabilized case, there is an error of 3 db from the logarithmic curve through the design points, but the response over an input range of 0.003 to 0.05v was logarithmic to one db. Since the tube selected for this work gives a logarithmic response with zero cathode resistance, it cannot be expected to yield the same logarithmic curve with a large resistance in the cathode. It must be emphasized that dc degeneration changes the transfer characteristic slightly. The curve degradation of the stabilized attenuator in this case should not be considered as a characteristic of this device. In some cases, notably when 6SK7 and 6SG7 pentodes are used, the response can be made logarithmic with large values of cathode resistance, while with a stability factor of unity the curve is not logarithmic. Since the shape of the transfer characteristic can be altered slightly by the insertion of the cathode resistance, greater latitude in tube selection is possible when the response characteristic is a prime consideration.

For a similar low-impedance attenuator, the results are shown in Figs. 5 and 6. The stability improvement of this attenuator is slightly greater than that obtained in the high-impedance case. When the supply voltage is reduced by one-half, the maximum change in the response is 18 db for the unstabilized attenuator as compared to 2 db in the stabilized case.

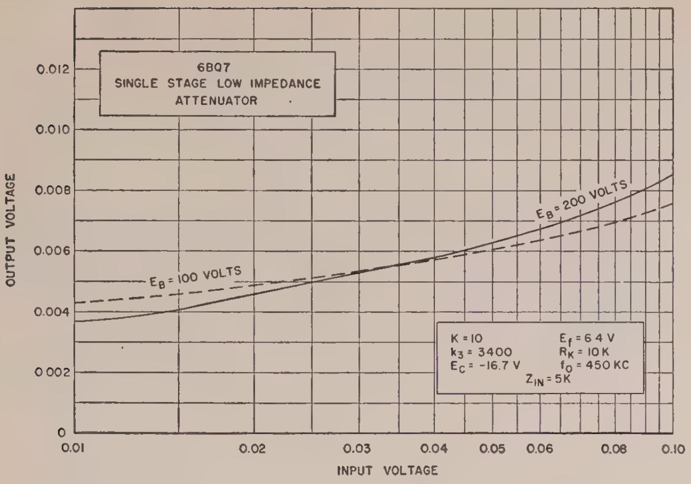


Fig. 5—Response of low-impedance attenuator with stabilization.

The experimental result for a two-stage high-impedance attenuator is given in Fig. 7. This attenuator uses both sections of a 6BQ7 and is logarithmic within 2 db over a 60-db range.

A low-impedance cascade attenuator using 6SG7 tubes connected as pentodes resulted in a unit which was logarithmic within one db over a 60-db range. The screen voltage for pentode operation may be obtained from either a high- or low-impedance source.

The design procedure in Appendix is not suitable with pentodes since screen-to-cathode voltage changes with input level. In general, design of a pentode attenuator is best done by experimental methods.

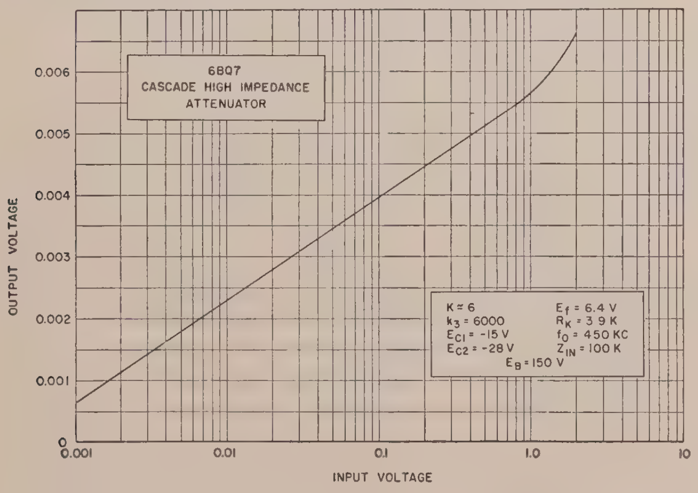


Fig. 7—Response of high-impedance cascade attenuator.

CONCLUSION

The variable electronic-impedance attenuator is shown to be effectively stabilized by the application of dc degeneration and a suitable increase in the loop gain. The use of these devices will result in an attenuator which is well suited for instrumentation since it is substantially less sensitive to electrode voltages, tube aging, temperature effects, etc., than some of the other types of commonly used attenuators.

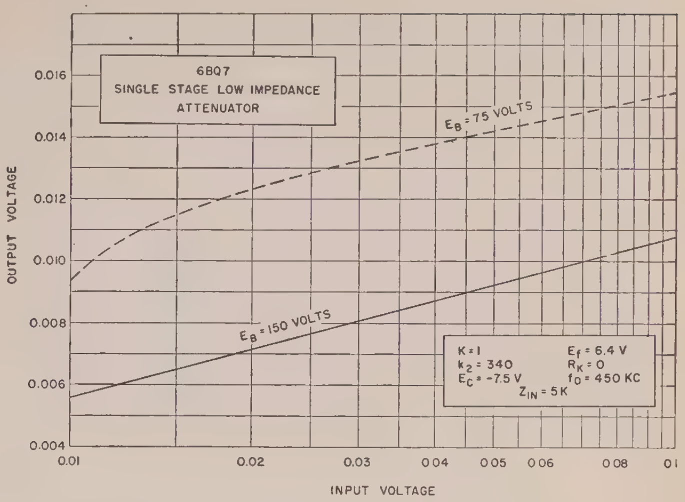


Fig. 6—Response of low-impedance attenuator without stabilization.

The application of dc degeneration results in a change in the shape of the transfer characteristic. In cases where a stable precision logarithmic attenuator is required, the design engineer must select a tube capable of providing a logarithmic response with the desired stability factor. When the stability factor is secondary, considerable latitude may be exercised in tube selection.

The calculated response, as obtained from the design procedure, for the high-impedance attenuator was found to consistently check the experimental result within one db.

Available tube data frequently will not provide the required information for the low-level design point. In that event the designer may use the data given and thus restrict the calculated range. The low-level operation may then be determined experimentally.

The bias of successive stages of cascaded attenuators should be determined experimentally since the response curve of the second stage must be blended with the characteristic of the first stage, and the response of the third stage blended with that of the second stage.

The stabilization technique described may also be applied to the AGC type of amplifier by returning the grid to a positive voltage applied through the detector. The circuit arrangement must be such that the detector is not biased with this connection. This application has been made experimentally in the laboratory by suitable modification of the design procedure.

ACKNOWLEDGMENT

The author wishes to express his appreciation to N. C. Hekimian, of the National Bureau of Standards, for his valuable assistance in the preparation of this paper.

APPENDIX I

DESIGN PROCEDURE FOR LOW-IMPEDANCE ATTENUATOR

Given: Desired value of stability improvement K, input impedance, and operating range in terms of both input and output voltages.

1. Using given values of E_o and E_i, solve (1) simultaneously for k_1 and C, using paired values of input and output voltages, at the highest and lowest level.
2. Choose value of R_2 as large as practical. A typical value might be 25,000 ohms for the low-impedance attenuator and R_3 might be 150,000 ohms in the high-impedance case.
3. Choose R_1 as dictated by input-impedance requirements. In most cases sufficient accuracy will be obtained if the impedance is considered as equal to R_1.
4. Select a tube with an approximately logarithmic $g_m - E_g$ characteristic over a considerable range.
5. Using the given values of E_o and E_i solve,

$$g_m = \frac{1}{R_2R_1}\left[\frac{R_2E_i}{E_o} - R_1 - R_2\right]$$

for the values of g_m at the design points of the attenuator.

6. Using the $g_m - I_p$ characteristic, find the values of I_p corresponding to the values of g_m obtained in 5. This assumes that g_m is a function of plate current but independent of plate voltage.
7. On the plate characteristic, for the design plate voltage and zero cathode resistance, find the values of E_g for the values of I_p found in 6. Using these values of E_g, solve (3) simultaneously for k_2.
8. Determine the required amplifier gain k_3,

$$b_3 = Kk_2$$

If k_3 is too large, a smaller value of K must be selected.

9. Assume a trial value of R_K. On the plate characteristic, construct a load line for this value of R_K. Find the values of E_g corresponding to the plate currents obtained in 6.
10. Using the values of voltage and current corresponding to the design points, solve,

$$E_g = Kk_2E_o + E_c - I_pR_K$$

simultaneously for R_K.

11. If the second value of R_K differs appreciably from the first, construct a new load line for the second value of R_K and again determine E_g. Repeat 10, solving for a third value of R_K. If the third value of R_K differs appreciably from the second, continue the approximation as required.
12. From the value of R_K found in 11, solve

$$E_g = Kk_2E_o + E_c - I_pR_K$$

for the fixed bias E_c.

The above procedure determines all necessary parameters for the attenuator. In some cases, it is desirable to determine a calculated response of the attenuator. In particular, it may be necessary to determine the attenuator response outside of the design range. A procedure for determining the calculated response follows.

13. Tabulate at least ten values of E_o. Plot $I_p - E_g$ for R_K. Choose a trial value of E_g at a given E_o. From the $I_p - E_g$ characteristics, find I_p for this value of E_g. Solve $E_g = E_1 + E_c - I_p R_K$ for E_g. If this value of E_g checks the trial value, this is the correct solution. If this is not the case, successive approximations for E_g should be made until the calculated value checks the trial value. I_p should be determined for each tabulated value of E_o.
14. For each value of I_p find the corresponding value of g_m from the $g_m - I_p$ characteristic. (This is an approximation since E_p is not constant.)
15. Solve for E_i for each value of E_o, from $E_i = E_o(1 + R_1(g_m + 1/R_2))$.
16. Plot attenuator response E_i vs E_o from these data.

The calculated response curve may be used to check the performance of experimental attenuators.

APPENDIX II

DESIGN PROCEDURE FOR HIGH-IMPEDANCE ATTENUATOR

Given: Desired value of stability improvement K, input impedance, and operating range in terms of both input and output voltages.

1, 2, 3. Repeat from previous design procedure.

4. Select a tube with an approximately logarithmic $g_m - E_g$ characteristic over a considerable range. The $r_p - E_g$ characteristic will be approximately inversely logarithmic if the amplification factor is assumed to remain constant.
5. Using the given values of E_o and E_i, solve,

$$r_p = \frac{R_1R_3E_o}{R_3E_i - (R_1 + R_3)E_o}$$

for the values of r_p at the design points of the attenuator.

6. From the curves of r_p vs I_p, find, for above values of r_p, the corresponding I_p. This assumes that r_p is a function only of I_p.

7, 8, 9, 10, 11, 12. Repeat from previous design procedure.

To determine the calculated response of the attenuator:

13. Repeat from previous design procedure.
14. From the curves of $r_p - I_p$, find for the values of I_p from 13, the corresponding r_p.
15. Find the corresponding values of E_i from

$$E_i = \frac{R_1E_o}{r_p} + \frac{E_o(R_1 + R_3)}{R_3}.$$

16. Plot the attenuator response curve E_i vs E_o from these data.

Geometric Aspects of Least Squares Smoothing*

ARTHUR A. HAUSER, JR.†, MEMBER, IRE

Summary—An understanding of the operation of a least squares smoother is enhanced by establishing an m-dimensional space in which inputs and outputs are vectors and the smoother is a transformation. The concept of transmission and rejection manifold as established by Zadeh is introduced and the manner in which signal and noise are separated is illustrated geometrically. An explicit pictorial representation of the process is given for the three dimensional case.

INTRODUCTION

IN RECENT PAPERS Shannon[1,2] and Zadeh[3] have made effective use of function space techniques in clarifying concepts in Communication Theory.

In this paper these geometrical techniques are applied to the problem of data smoothing with the object of illustrating the mechanism by which data smoothing is accomplished. Least squares smoothing has been chosen for consideration because it permits of convenient geometric representation and also is of considerable practical importance.

Least squares estimation for the nonrandom parameter case is a special form of Maximum Likelihood Smoothing which results when normally distributed uncorrelated noise is assumed. The smoother in this case turns out to be linear and the problem of synthesis is essentially one of determining its weighting function. The problem may be formulated as follows:

Consider a function $x(t)$ given by

$$x(t) = a + bt + n(t)$$

where $n(t)$ is a normally distributed uncorrelated random function of time. Let this function be sampled at time $t_1, t_2, \cdots, t_m$ thus forming the sequence $x_1 x_2, \cdots, x_m$. Suppose that this sequence constitutes the input data to a system. The problem is to characterize the system such that its output will be the optimum estimate of the nonrandom portion of $x(t)$ at time $t = t_m$ in the maximum likelihood sense. For normally distributed uncorrelated noise this is equivalent to characterizing a system which gives a least squares estimate of the value of the nonrandom portion of $x(t)$ at $t = t_m$.[4] It should be kept in mind that $x(t)$ is continually being sampled at equal intervals, Δt, of time where $\Delta t = t_k - t_{k-1}$ and that this sampled data is being impressed on the system but that in forming the output the system uses only the most recent m measurements. That is, the system has a finite memory of $(m-1)\,\Delta t$ seconds.

If y_m represents the required estimate of the nonrandom portion of $x(t)$ at time $t = t_m$ and ν_n represents the maximum likelihood estimate of the time rate of change of the nonrandom portion of $x(t)$ at time $t = t_m$, then these parameters (y_m and ν_m) are determined by the condition that

$$\epsilon^2 = \sum_{\mu=0}^{m-1} [x_{m-\mu} - (y_m - \mu \nu_m \,\Delta\, t)]^2 = \text{a minimum.} \quad (1)$$

Differentiating ϵ^2 separately with respect to y_m and ν_m leads to two linear equations in y_m and ν_m which when solved for y_m give

$$y_m = \sum_{\mu=0}^{m-1} \frac{4m - 6\mu - 2}{m(m+1)} x_{m-\mu}.$$

A similar solution for ν_m may be found readily if it is desired to characterize a maximum likelihood differentiator. The least squares smoother is therefore a linear system with weighting function:

$$W_\mu = \frac{4m - 6\mu - 2}{m(m+1)}.$$

The noise reduction which is realizable with such a smoother is found by using the property of linearity of the filter and assuming the input is noise (uncorrelated and Gaussian) alone with variance σ_x^2. The variance σ_y^2 of the noise on the output is then given by

$$\frac{\sigma_y^2}{\sigma_x^2} = \frac{2(2m-1)}{m(m+1)}$$

which approaches $4/m$ for large m.

These results are well known and may be obtained by other methods. In particular they occur as a degenerate case of theory presented by Zadeh and Ragazzini.[5] The advantage of the method of derivation used here is in the ease with which a sequence-space interpretation of the smoothing process may be made. Before discussing the geometric interpretation of the smoothing process, a few definitions and theorems relating to sequence spaces will be given.

THE SEQUENCE SPACE

By a sequence space shall be meant an m-dimensional linear vector space S with an orthonormal basis: $(1, 0, 0, \cdots, 0)$, $(0, 1, 0, \cdots, 0)$, $\cdots$, $(0, 0, \cdots, 1)$.

---

* Decimal classification: 510. Original manuscript received by the Institute, May 14, 1953; revised manuscript received, November 19, 1953.

† Sperry Gyroscope Co., Great Neck, N. Y.

[1] C. E. Shannon, and W. Weaver, "The Mathematical Theory of Communication," Univ. of Ill. Press, Urbana, Ill.; 1949.

[2] C. E. Shannon, "Communication in the presence of noise," PROC. I.R.E., vol. 37, pp. 10–21; January, 1949.

[3] L. A. Zadeh, "Some Basic Problems in Communication of Information," Trans. of The N. Y. Acad. of Sci., series II, vol. 14; 1952.

[4] A. Mood, "Introduction to the Theory of Statistics," McGraw-Hill Book Co., New York, N. Y., chap. 8; 1950.

[5] L. A. Zadeh and J. R. Ragazzini, "An extension of Wiener's theory of prediction," *Jour. Appl. Phys.*, vol. 21; 1950.

U. OF T. LIBRARY

Definition 1

Associated with each vector $\mathbf{x}$ in S is a number called its norm $\|\mathbf{x}\|$. This number is defined by the relation

$$\|\mathbf{x}\|^2 = \sum_{\mu=1}^{m} x_\mu^2.$$

Definition 2

The sum (difference) of two vectors $\mathbf{x}_1=(x_{11}, x_{12}, \cdots, x_{1m})$ and $\mathbf{x}_2=(x_{21}, x_{22}, \cdots, x_{2m})$ is in S and defined by the relation:

$$\mathbf{x}_1 \pm \mathbf{x}_2 = (x_{11} \pm x_{21}, x_{12} \pm x_{22}, \cdots, x_{1m} \pm x_{2m}).$$

Definition 3

The distance between two vectors x_1 and x_2 is denoted by the symbol $d(\mathbf{x}_1, \mathbf{x}_2)$ and is defined to be:

$$d(\mathbf{x}_1, \mathbf{x}_2) = \|\mathbf{x}_1 - \mathbf{x}_2\|.$$

Definition 4

The projection $P_A\mathbf{x}_1$ of $\mathbf{x}_1$ on a subspace A of S is a vector $\boldsymbol{y}_1$ in A defined by the property that

$$d(\mathbf{x}_1, \boldsymbol{y}_1) = \text{minimum over } A.$$

Definition 5

Subspace M of means is defined as that subspace of S spanned by vector $\boldsymbol{\xi}=(1, 1, 1, \cdots, 1)$. M is a one-dimensional subspace and will be called line of means.

Corollary 5.1: The subspace M of means contains all vectors of the form

$$\boldsymbol{\xi} = (K, K, \cdots, K), \text{ and only these.}$$

Definition 6

The mean of $\mathbf{x}$ is its projection on M.

Theorem 1: The components of the mean of $\mathbf{x}$ are all equal to the mean value of the components of $\mathbf{x}$.

Proof: Let $\boldsymbol{\xi}=P_M\mathbf{x}=$mean of $\mathbf{x}$.

Then $d(\mathbf{x}, \boldsymbol{\xi})=$a minimum over M.

But by corollary 5.1 $\boldsymbol{\xi}$ has the form:

$$\boldsymbol{\xi} = (K, K, \cdots, K).$$

Therefore

$$[d(\mathbf{x}, \boldsymbol{\xi})]^2 = \sum_{v=1}^{m} (x_v - K)^2$$

and d is a minimum for

$$\frac{\partial d^2}{\partial K} = -2 \sum_{v=1}^{x} (x_v - K) = 0.$$

Therefore

$$K = \frac{\sum_{v=1}^{m} x_v}{m}.$$

Definition 7

With each vector $\mathbf{x}$ of S is associated a second vector $\boldsymbol{\delta}$ whose norm measures the dispersion of $\mathbf{x}$.

$$\boldsymbol{\delta} = \frac{\mathbf{x} - \boldsymbol{\xi}}{\sqrt{m}}.$$

Corollary 7.1:

$$\sigma^2 = \|\boldsymbol{\delta}\|^2 = \frac{\sum_{v=1}^{m} (x_v - \xi)^2}{m}.$$

Definition 8

The *inner product* $(\mathbf{x}_1, \mathbf{x}_2)$ of the two vectors $\mathbf{x}_1=(x_{11}, x_{12}, \cdots, x_{1m})$ and $\mathbf{x}_2=(x_{21}, x_{22}, \cdots, x_{2m})$ is defined to be

$$(\mathbf{x}_1, \mathbf{x}_2) = \sum_{v=1}^{m} x_{1v}x_{2v}.$$

Definition 9

The cosine $\cos \theta_{12}$ of the angle θ_{12} between the two vectors $\mathbf{x}_1$ and $\mathbf{x}_2$ is defined to be:

$$\cos \theta_{12} = \frac{(\mathbf{x}_1, \mathbf{x}_2)}{\|\mathbf{x}_1\| \|\mathbf{x}_2\|}.$$

Definition 10

The correlation coefficient ρ_{12} between the two samples $\mathbf{x}_1$ and $\mathbf{x}_2$ is defined to be the cosine of the angle ϕ_{12} between the vectors $\boldsymbol{\delta}_1$ and $\boldsymbol{\delta}_2$ associated with $\mathbf{x}_1$ and $\mathbf{x}_2$ respectively, i.e.,

$$\rho_{12} = \cos \phi_{12} = \frac{(\boldsymbol{\delta}_1, \boldsymbol{\delta}_2)}{\|\boldsymbol{\delta}_1\| \|\boldsymbol{\delta}_2\|}.$$

The definitions just given are illustrated geometrically for $S=3$ in Fig. 1.

LEAST SQUARES SMOOTHING IN SEQUENCE SPACE

The input sequence $x_m, x_{m-1}, \cdots, x_1$ may be represented as a vector $\mathbf{x}$ in S where

$$\mathbf{x} = (x_m, x_{m-1}, \cdots, x_1). \tag{2}$$

Denoting by $\boldsymbol{y}$ the vector

$$\boldsymbol{y} = (y_m, y_m - v_m\Delta t, y_m - 2v_m\Delta t, \cdots, y_m - (m-1)v_m\Delta t) \tag{3}$$

it is seen that the condition imposed by the least squares criterion as expressed in (1) may be written:

$$\|\mathbf{x} - \mathbf{y}\| = \text{a minimum.} \tag{4}$$

That is, y_m and v_m must be so selected that the resulting vector $\boldsymbol{y}$ is as close to the input vector $\mathbf{x}$ as possible. The actual output of the system at time $t=t_m$ is then the first component, $\boldsymbol{y}_m$, of $\boldsymbol{y}$.[6]

Now, if y_m and v_m are allowed to vary it will be noticed that y is constrained by (3) to lie in a plane and this plane contains the line of means as may be seen by setting $v_m=0$ in (3). Denoting this plane by X, the least squares condition (4) may be expressed by writing

$$\boldsymbol{y} = P_X\mathbf{x}. \tag{5}$$

---

[6] Note that the $k+1$st component of $\mathbf{y}$ does not represent the output of the system at time t_{m-k} for $k\neq 0$.

It is readily shown that this condition is equivalent to requiring that **x** and *y* have same mean values, i.e.,

$$\xi = \xi_x = \xi_y \tag{6a}$$

and that the line joining **x** to *y*, i.e., the vector $\boldsymbol{\varepsilon} = \mathbf{x} - \boldsymbol{y}$ be orthogonal to the vector $\boldsymbol{\xi} - \boldsymbol{y}$. That is that

$$(\mathbf{x} - \boldsymbol{y}, \xi_y - \boldsymbol{y}) = 0. \tag{6b}$$

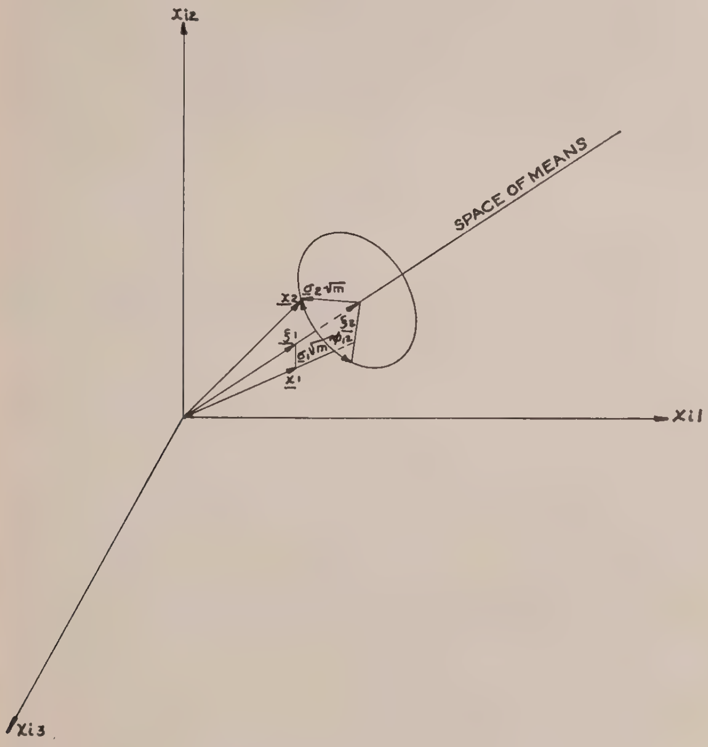


Fig. 1—A three-dimensional vector space showing quantities of major interest.

On writing out the relations (6a) and (6b) in scalar form the expression for y_m in terms of x_j and therefore for W_v obtained in the introduction is found.

The geometry of the smoother is illustrated for $m=3$ in Fig. 2. The plane X into which the input vector **x** is projected to find *y* is shown and the geometrical significance of conditions (6a), (6b) is made evident.

Discussion of the Geometry of the Least Squares Smoother

The properties of the smoother can be best discussed in terms of its transmission and rejection manifolds.[3] The transmission manifold of the smoother is that subspace Γ, of S such that if the input lies in Γ, the output (in the steady state) will equal the input. That is, the transmission manifold of the smoother is the set of all inputs which are passed unaltered by the smoother. The rejection manifold of the smoother is that subspace, Y, of S such that if the input lies in Y the output of the smoother (in the steady state) is zero.

From (5) it is seen that if and only if **x** is in X then *y* will be equal to **x**. X is the transmission manifold of the smoother. Letting $\xi_1, \xi_2, \cdots, \xi_m$ denote the components of a vector in X,

$$\xi_\mu = y_n - (\mu - 1)v_m\Delta t \tag{7}$$

showing that the m co-ordinates are linearly related and depend on two parameters, y_m and v_m. Hence the transmission manifold is a plane composed of all linear functions of time. Thus the smoother passes linear functions without distortion in the steady state.

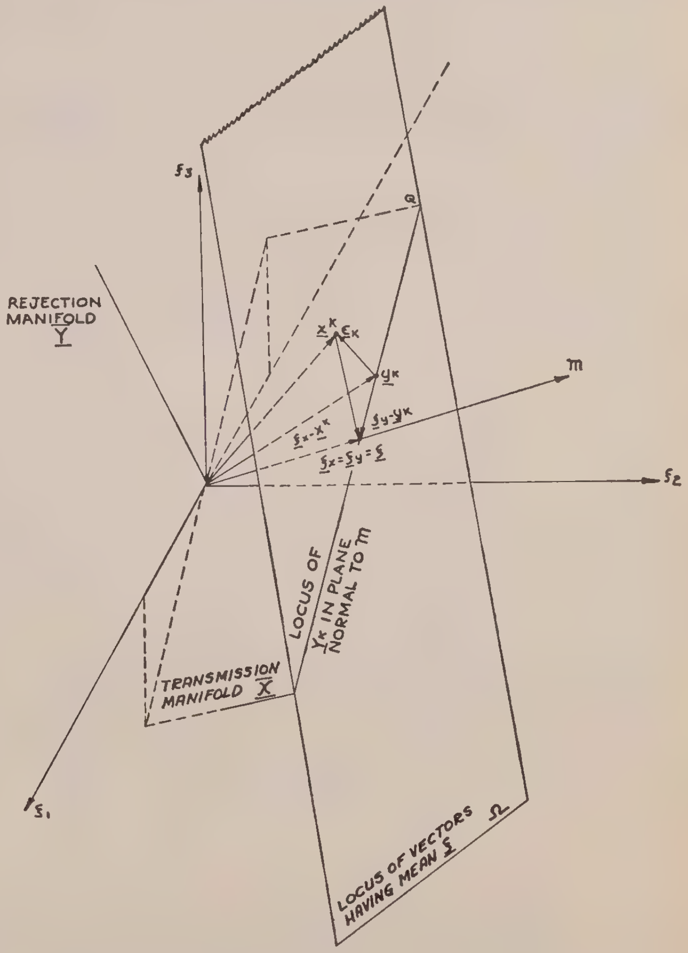


Fig. 2—Three-dimensional illustration of minimization process.

A given input is projected into X in obtaining the output, and this projection is an orthogonal projection as may be verified from the definitions of projection and angle between vectors given previously. Hence, the rejection manifold, Y, must be orthogonal (this is not generally the case) to X, and is therefore the intersection of the two hyperplanes:

$$\sum_{\mu=1}^{m} \xi_\mu = 0$$
$$\sum_{\mu=1}^{m} \mu\xi_\mu = 0 \tag{8}$$

where $\xi_\mu(\mu = 1, 2, \cdots, m)$ are now the components of a vector in Y. The first of these conditions states that the mean of any vector in Y is zero, i.e., $P_m Y = 0$, and the second may be shown to be equivalent to the statement that the vectors in Y are uncorrelated with the vectors in X. The smoother rejects this class of inputs.

Referring now to Fig. 3 in which the case $m=3$ is again depicted, the transmission manifold X and rejection manifold Y are shown. The transmission manifold,

X, is the plane given by

$$2\xi_2 = \xi_1 + \xi_3$$

while the rejection manifold, Y, is the line defined by the intersection of the two planes

$$\xi_1 + \xi_2 + \xi_3 = 0$$

$$\xi_1 + 2\xi_2 + 3\xi_3 = 0$$

that is, the rejection manifold, Y, has the direction numbers

$$1,\ -2,\ 1.$$

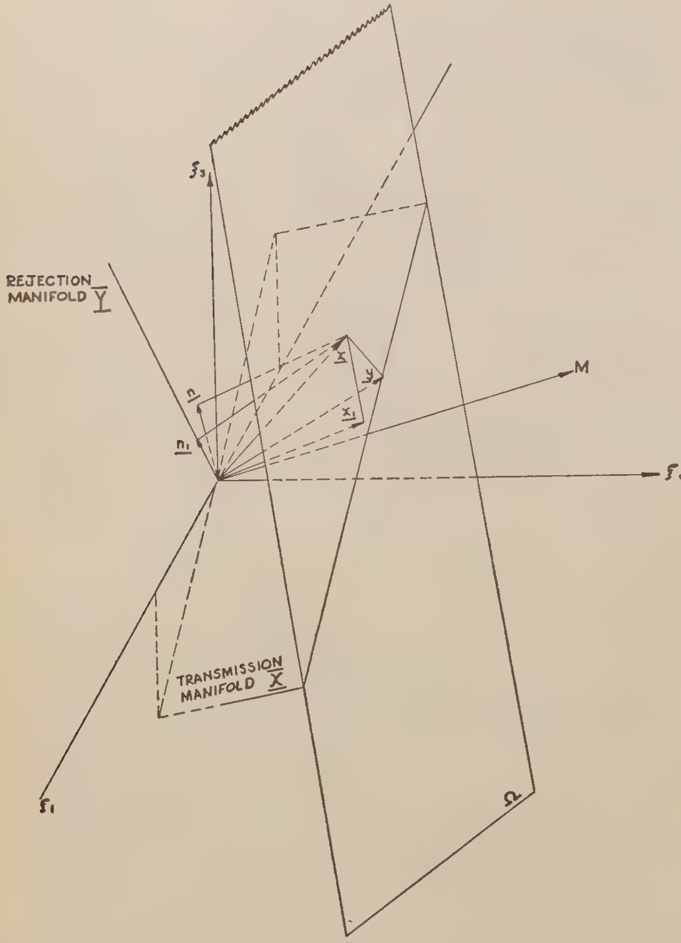


Fig. 3—Illustration of ideal and actual separation of input into signal and noise.

The input $\mathbf{x}$ is also shown broken down into its two components namely the random component $\boldsymbol{n}$ and the nonrandom component $\mathbf{x}_1$. The smoother has no knowledge of this decomposition of $\mathbf{x}$ but attempts to accomplish this breakdown by projecting $\mathbf{x}$ into the transmission manifold X forming $\boldsymbol{y}$ which is the estimate of $\mathbf{x}_1$ and rejecting the projection, $\boldsymbol{n}^1$, of $\mathbf{x}$ into Y which is the system's estimate of $\boldsymbol{n}$. Ideal filtering can occur only if $\boldsymbol{n}$ lies entirely in the rejection manifold in which case $\boldsymbol{n}^1 = \boldsymbol{n}$ and $\boldsymbol{y} = \mathbf{x}_1$. This, of course, cannot occur on the average but is approached as m is increased. To see that increasing m causes the noise to fall more nearly in the rejection manifold, note that increasing m means increasing sample size and therefore the condition

$$\sum_{\mu=1}^{m-1} \xi_\mu = 0$$

is more nearly satisfied. Further, increasing m corresponds to increasing the dimensionality of S so that the number of dimensions orthogonal to X which is m—2 is increased. Now since $n(t)$ is uncorrelated, successive samples tend to form planes with the line of means which are mutually orthogonal. As m is increased there are more degrees of freedom in which this may occur since there are more directions orthogonal to X. This implies less correlation between the noise and vectors in X. That is, as m is increased

$$\sum_{\mu=1}^{m-1} \mu\xi_\mu = 0$$

is more nearly satisfied.

Therefore, increasing m means that the relations (8) are more nearly satisfied and hence the noise lies more nearly in the rejection manifold.

The transmission manifold as determined by the least squares criterion insures that linear functions of time are passed without distortion in the steady state. The reason for this is evident when it is observed that X is actually the locus of all vectors having components given by (7) for every possible pair of values of the two parameters y_m and v_m. It should be noticed that the sum of the dimensions of the transmission and rejection manifold is the dimension of the sequence space. This fact remains valid for least squares smoothing when the trend is of higher order than linear.

Consider now a least squares smoother which is designed to pass a trend of higher order than linear, say quadratic. The basic equation defining the filter is still the same, i.e.,

$$\|\mathbf{x} - \boldsymbol{y}\| = \text{a minimum}$$

which states that the projection, $\boldsymbol{y}$, of the input, $\mathbf{x}$, into the transmission manifold, X, must be as close to the input, $\mathbf{x}$ as possible. In this case the transmission manifold is a three-dimensional linear subspace of S and of course must include the two-dimensional subspace which was the transmission manifold of the smoother designed to pass a linear trend. Thus for the same amount of noise on the input, the projection of the noise vector into the transmission manifold of the quadratic trend smoother will be at least as great as for the linear trend smoother. This means that the noise reduction in the linear trend smoother is always at least as great as in the quadratic trend smoother.

In general, from the discussion just given it is clear that the noise reduction in a smoother capable of passing a polynomial trend of degree N must be at least as great as the noise reduction in a smoother designed to pass a polynomial of degree $N+1$.

ACKNOWLEDGMENT

Much of the background required for this paper was obtained through a seminar given during 1953 at Columbia University, under the direction of Professor L. A. Zadeh.

Radio Progress During 1953[*]

CONTENTS

Facsimile 705
Wave Propagation 706
Industrial Electronics 713
Television Broadcasting 715
Piezoelectricity 717
Electron Tubes 720
Semiconductors 725
Antennas and Waveguides 728
Sound Recording and Reproducing 730
Information Theory and Modulation Systems 732
Navigation Aids 734
Electroacoustics 735
Vehicular Communications 737
Radio Transmitters 738
Electronic Computers 739
Quality Control 745
Radio Telemetering and Remote Control 745
Magnetics 745
Instrumentation and Measurements 746
Feedback Control Systems 749
Circuits 751
Video Techniques 755
Audio Techniques 756
Receivers 758

Introduction

IN PREPARING THIS REVIEW of Radio Progress in 1953 the Annual Review Committee has endeavored to present the major happenings in each technical branch of radio engineering with the objective of giving the engineer engaged in a particular line of activity a general report of the developments in other fields. This presentation is not primarily intended to inform experts in their own technologies, but it includes references to the more significant publications for the convenience of readers who may wish to inquire into further technical details of the developments mentioned.

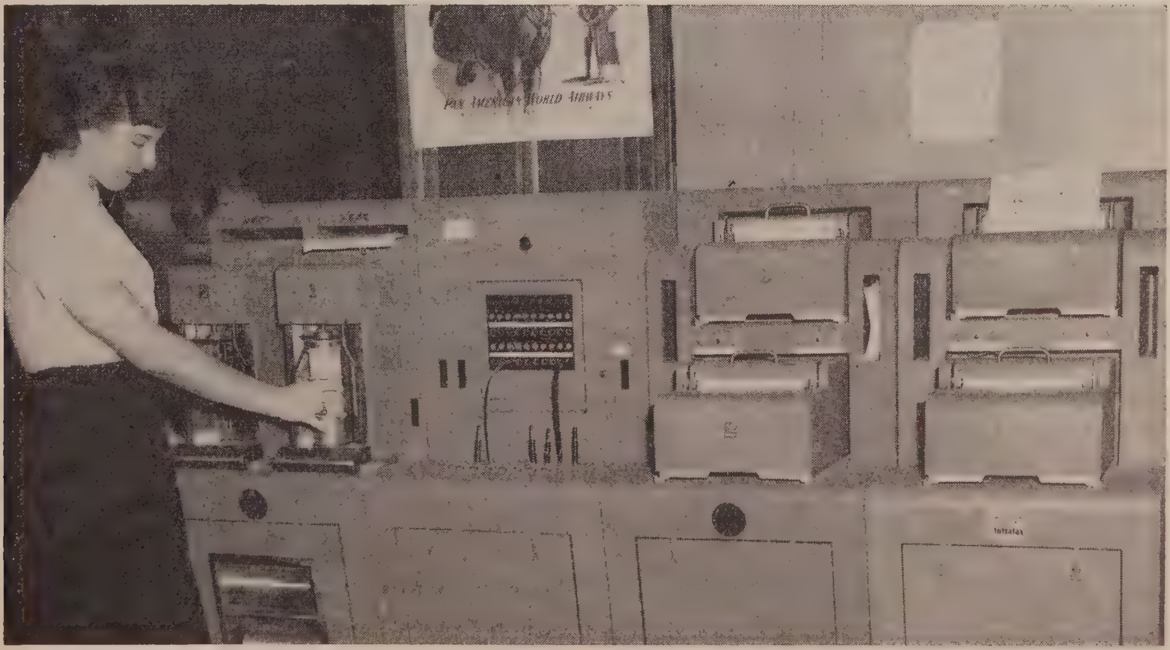
Facsimile

At the close of the year 11,300 Desk-Fax units were in operation connecting telegraph patrons with the nearest central office, in 50 major cities, thereby expediting terminal handling of telegraph-message traffic. The same type of equipment is used for handling bank transfers, Pullman-space reservations, and similar services.

(1) "Bank facsimile system handles billion-dollar-a-day transfers," *Telegr. and Teleph. Age*, vol. 70, p. 20; November , 1952.
(2) A. S. Hill, "Tickets by Telefax," *Western Union Tech. Rev.*, vol. 7, pp. 96–97; July, 1953.

Among the more recent applications of facsimile to public service and industry were the one that provides television studios with the news pictures for broadcasting, another that enables an electric power company to regulate its daily generating schedule more accurately; and a third that permits a small rural hospital to secure rapid interpretation of X-ray photographs from an expert roentgenologist located in another city miles away.

(3) J. V. L. Hogan and D. Frezzolini, "The facsimile transmission of news and news photographs for television." Presented at AIEE Summer General Meeting, Atlantic City, N. J.; June 15, 1953.
(4) T. P. Swift, "Facsimile device rules power flow, "*N. Y. Times*, sec. 3, pp. 1F, 4F; September 6, 1953.
(5) K. R. McConnell, "Transmitting X-ray photographs by facsimile." Presented at AIEE Summer General Meeting, Atlantic City, N. J.; June 15, 1953.



Intrafax installation, consisting of unitized consoles showing two transmitter positions, line-switching unit, and four recorder positions. (Courtesy of Western Union Telegraph Co.)

(6) J. H. Hackenberg, "Page-size facsimile transmitter," *Western Union Tech. Rev.*, vol. 7, pp. 21–22; January, 1953.
(7) J. Bell, J. A. B. Davidson, and E. T. A. Phillips, "Some recent

---

[*] Decimal classification: R090.1. Original manuscript received by the Institute, January 17, 1954. This report was prepared by the 1953 Annual Review Committee of the Institute of Radio Engineers.

developments in photo-telegraphy and fascimile transmission," *Proc. IEE* (*London*), vol. 99, part 3, pp. 344–359; November, 1952.

A phototelegraph transmitter-receiver and a system for level compensation were described.

(8) R. O. Carter and L. K. Wheeler, "A photo-telegraph transmitter-receiver utilizing sub-carrier frequency modulation," *Proc. IEE* (*London*), vol. 99, part 3, pp. 335–343; November, 1952.
(9) T. A. Jones and W. A. Phelps, "A level compensator for telephotograph systems." Presented at AIEE Summer General Meeting, Atlantic City, N. J.; June 15, 1953.

Wave Propagation

Ionospheric Propagation

Wave propagation in the upper atmosphere, beyond a height of about 60 km, is dependent upon the physical state of this region at the particular time and place. More than 300 references were found and many papers dealing with ionospheric propagation were presented at the Joint URSI-IRE meetings in Washington in April, 1953, and in Ottawa in October, 1953.

Lf and Vlf Propagation, Models of the Lower Ionosphere, SID

A nighttime layer, which is erratic in occurrence, was discovered through the use of the sweep-frequency pulsed recorder for the range 50 kc to 1 mc reported last year. This layer seems to have continuity with the daytime E-layer during sunset. Traces, characteristic of magnetoionic splitting, were observed for the new layer and also for layers below the E-layer. Daytime reflections were recorded from three distinct boundaries in the E-region, each quite sharp in ionic gradient, extending from about 70 km to over 100 km in virtual height. Turbulent conditions in the lower levels of the daytime E-region were sometimes observed.

(10) DSIR abstracts refer to those prepared by the Department of Scientific and Industrial Research in London and carried monthly in Proc. I.R.E.
(11) RIRJ abstracts refer to those carried in *Report of Ionospheric Research in Japan* (in English approximately quarterly) and distributed in the United States by the Smithsonian Institution.
(12) J. M. Watts and J. N. Brown, "Some results of sweep frequency investigation in the low frequency band," presented at joint URSI-IRE Meetings, Ottawa, Can., October, 1953.

A continuous-wave phase measuring technique for lf and vlf was described and preliminary results were presented. The system uses a horizontal transmitting antenna near low-conductivity ground and is resonant at the operating frequency. No ground wave is radiated in the direction of the receiver. The phase of the sky wave is compared with a reference phase transmitted over a vhf link.

(13) C. W. Bergman, R. S. Macmillan, and W. H. Pickering, "A new technique for investigating the ionosphere at low and very low radio frequencies." Presented at URSI-IRE Meeting, Nat'l Bur. of Stds., Washington, D. C., April, 1953.

An 1185-km-path pulse experiment at 300 kc was carried out between New Jersey and Bermuda. Nighttime reflection heights of about 90 km and daytime heights of about 70 km were found. Although there was some variability depending on the number of hops, the weak daytime sky wave observed ranged from $\frac{1}{10}$ to $\frac{1}{4}$ the amplitude of the ground wave. Increased absorption became effective rather abruptly about 35 minutes before the sea-level sunrise at the midpoint of the path. It was suggested that this may be caused by the disassociation of negative ions of atomic oxygen by solar rays tangent to the ozone layer, which extends down to a height of about 35 km. A sun-ray tangent to the ozone layer would be sufficient to explain the observations but only if the absorbing region is near the height of reflection. The possibility is not precluded that the absorbing region is below 80 km if a mechanism exists to liberate electrons in that region suddenly at the time of increased absorption.

An investigation led to the conclusion that sunrise effects noted at 150 kc are probably due to ionization of molecular oxygen by solar radiation of wavelength shorter than 910 Å.

At 16 kc and at a distance of about 540 km, the phase and amplitude of the received signal change suddenly about 1 hour before ground sunrise at the midpoint of the transmission path as a result of a lowering of the reflection height. It was shown that the pre-sunrise effect is explicable as a negative-ion phenomenon.

It was observed that the electron density reaches a maximum sometime after the rate of electron production reaches a maximum. Although quantitative results were for midday conditions, the effect will be manifest at sunrise and might be considered in the foregoing problem.

(14) J. M. Watts, "Oblique incidence propagation at 300 kc/s using the pulse technique," *Jour. Geophys. Res.*, vol. 57, pp. 487–498; December, 1952. DSIR abstract 1474.
(15) S. B. Brown and W. Petrie, "The effect of sunrise of the propagation of low frequency waves." Presented at the joint URSI-IRE Meeting, Ottawa, Can.; October, 1953.
(16) R. Lindquist, "An investigation of the ionizing effect in the E-layer near sunrise," *Jour. Geophys. Res.*, vol. 57, pp. 439–458; December, 1953. DSIR abstract 1346; see discussion by W. Pfister, *loc. cit.*, vol. 58, p. 282; June, 1953.
(17) E. V. Appleton, "A note on the 'sluggishness' of the ionosphere," *Jour. Atmos. Terr. Phys.* (Correspondence), vol. 3, pp. 282–284; June, 1953. DSIR abstract 3289.

Vlf propagation over great distances was analyzed by considering the earth and lower ionosphere as a waveguide. The propagation of 16-kc signals and vlf atmospherics were explained on this basis.

(18) K. G. Budden, "The propagation of very low-frequency radio waves to great distances," *Phil. Mag.*, vol. 44, pp. 504–513; May, 1953. DSIR abstract 2773.
(19) F. Hepburn and E. T. Pierce, "Atmospherics with very low-frequency components," *Nature*, vol. 171, pp. 837–838; May, 1953. DSIR abstract 2771.

A comprehensive summary of investigations of 150 kc was published, and daytime and nighttime models illustrating electron density variation with height was described. A discussion of theoretical group heights at this frequency was presented in a separate paper. A Japanese paper appeared which is in substantial disagreement with the models.

(20) R. J. Nertney, "The lower E- and D-region of the ionosphere as deduced from long wave measurements," Penn. State Coll., Ionosphere Res. Lab., Scientific Rpt. 39, contract AF 19(122)-44, TIP U25157; June, 1952. *Jour. Atmos. Terr. Phys.*, vol. 3, pp. 92–107; February, 1953. DSIR abstract 2306.
(21) N. Davids, "Theoretical group heights of reflection of 150 kc/s radio waves vertically incident on the ionosphere," *Jour. Atmos. Terr. Phys.*, vol. 2, pp. 324–336; 1952. DSIR abstract 516.

(22) T. Sato, "The electron density of the D-region," *Jour. Geomag. Geoelec.*, vol. 4, no. 44; 1952, RIRJ abstract, vol. 7, no. 1, p. 39 (I-1); 1953.

Propagation at frequencies lower than 3 mc at ranges mainly greater than 500 km was reviewed.

(23) F. A. Kitchen, B. G. Pressey, and K. W. Tremellen, "A review of present knowledge of the ionospheric propagation of vlf, lf, and mf waves," *Proc. IEE* (Part 3), vol. 64, pp. 100–108; March, 1953. DSIR abstract 1781.

Sudden ionospheric disturbances (SID), arising from solar flares, received further attention. Observations at 16 kc at a range of about 500 km showed a change in phase of the received signal but not of amplitude. An explanation was given which was based on the behavior of two layers below the E-layer.

A general survey of the subject of SID led to the following conclusions: 1) Enhancement of the negative-ion to electron ratio does not occur. 2) The degree of enhancement of ionization is the same at all levels of the D-region, and appears to be an intensification and not a new distribution. It seems likely that both the normal and enhanced ionizations in this region are caused by photo-ionization of *NO* by $L\alpha$. 3) The intensities of the $L\alpha$ radiation are about 6, 20, and 100 times the normal value for class 1, 2, and 3 flares, respectively. 4) The flare current system is located either at 90 km (at the same level as the Sq-current) or is an independent system located at 60 km.

Japanese observers reported on the effects in the *upper* ionosphere at the time of solar flares.

(24) W. C. Bain, "Observations on the propagation of very long radio waves reflected obliquely from the ionosphere during a solar flare," *Jour. Atmos. Terr. Phys.*, vol. 3, pp. 141–152, April, 1953; DSIR abstract 2769.
(25) A. P. Mitra, "Theory of sudden ionospheric disturbances," presented at the Joint URSI-IRE Meeting, Ottawa, Can.; October, 1953.
(26) Y. Nukata and K. Araki, "Rapid changes of the ionospheric state at the time of a solar flare," *Proc. Semi-Annual Meeting CRWO*, no. 3, p. 25; 1951, RIRJ abstract I-26.

Absorption

Nearly twenty papers appeared on the absorption of radio waves in the ionosphere. Theoretical analysis showed that in the D and E regions, the electron-collision frequency depends on the neutral-particle concentration and in the F region on the electron concentration.

(27) W. R. Piggott, "The reflection and absorption of radio waves in the ionosphere," *Proc. IEE* (Part 3), vol. 64, pp. 61–72; March, 1953. DSIR abstract 1679.
(28) B. Chatterjee, "Studies on ionospheric absorption," Univ. of Calcutta, Inst. of Radio Phys. and Electronics, *Res. Rpt.*, vol. 4, part 2, pp. 32–45; 1952–53.
(29) M. Nicolet, "The collision frequency of electrons in the ionosphere," Penn. State Coll. Scientific Rpt. 32, contract AF 19(122)44, TIP U22851, February, 1952. *Jour. Atmos. Terr. Phys.*, vol. 3, pp. 200–211; May, 1953. DSIR abstract 3299.

Vertical Incidence Reflections Near the Gyro-Frequency from the D-Region

In England in January and February, 1951, reflections were obtained in the region of 1.4 mc from heights between 75 and 80 km using a sensitive frequency modulation method suitable for detecting echoes at times of high absorption.

In Germany, reflections were obtained at frequencies of 1.6–4.0 mc at heights of 75–100 km., evidently produced by a partial reflection at a sharp boundary in an ionization region extending downwards from the E region. Solar control is indicated. Nighttime echoes obtained at 95 km are attributed to meteoric ionization.

At an extremely low-noise receiving site in Australia, echoes have been obtained at 2 mc and at heights down to about 60 km. The observations reveal a region at about 70 km where distinct strata form by day and a region of greater electron density at about 90 km which extends up to the normal E region.

(30) S. Gnanalingam and K. Weekes, "Weak echoes from the ionosphere with radio waves of frequency 1.42 mc/s," *Nature*, vol. 170, pp. 113–114; July, 1952. DSIR abstract 3427 of 1952.
(31) W. Dieminger, "On causes of excessive absorption in the ionosphere on winter days," *Jour. Atmos. Terr. Phys.*, vol. 2, pp. 340–349 (In German with English abstract); 1952. DSIR abstract 519.
(32) F. F. Gardner and J. L. Pawsey, "Study of the ionospheric D-region using partial reflections," *Jour. Atmos. Terr. Phys.*, vol. 3, pp. 321–344; July, 1953.

Hf Propagation

A new technique for solving the general problem of hf ionospheric propagation was outlined. A particularly comprehensive calculation of hf propagation over the 4,000 km path between Washington, D. C. and Stanford, California was carried out. A nomogram was presented for calculating the geometry of skywave problems.

(33) A. H. de Voogt, "The calculation of the path of a radio-ray in a given ionosphere," PROC. I.R.E., vol. 41, pp. 1183–1186; September, 1953.
(34) L. H. Bixby, Jr., "Calculation of high frequency radio field intensity over a 4000 km ionospheric path," Stanford University, Radio Prop. Lab., prepared under Bur. of Stds. Contract CST-10751; May, 1953.
(35) R. A. Helliwell, "Graphical solution of sky-wave problems," *Electronics*, vol. 26, pp. 150–152; February, 1953. DSIR abstract 1469.

Additional oblique-path pulse experiments further sustained the validity at hf of standard ray-path calculations which neglect the geomagnetic field. Observations at high latitudes, however, showed marked distortion apparently due to ionospheric turbulence. This is not surprising in view of the common occurrence of spread echoes on vertical-incidence records taken at high latitudes.

(36) S. S. Baral and A. K. Saha, "Observations at Calcutta of pulses transmitted from Delhi," *Ind. Jour. Phys.*, vol. 26, pp. 521–528; November, 1952. DSIR abstract 2116. Also: Univ. of Calcutta, Inst. of Radio Phys. and Electronics, *Res. Rpt.*, vol. 4 (1952–53), part 2, pp. 46–75.
(37) M. Strohfeldt, R. W. E. McNicol, and G. de V. Gipps, "Ionospheric measurements at oblique incidence over eastern Australia," *Aust. Jour. Sci. Res.*, Ser. A, vol. 5, pp. 464–472; September, 1952. DSIR abstract 807.
(38) B. Wieder, P. G. Sulzer, and J. W. Wright, "The NBS oblique path sweep frequency experiment," presented at URSI-IRE Meeting, Nat'l. Bur. of Stds., Washington, D. C.; April, 1953.
(39) "Sweep frequency pulse test of oblique incidence," *Proc. Semi-Ann. Meet. CRWO*, vol. 45; 1952. RIRJ abstract R-2.
(40) J. Bouchard, "Ionospheric propagation of decameter waves in the arctic polar regions," *Compt. Rend. Acad. Sci.* (Paris), vol. 236, pp. 220–222; January, 1953. DSIR abstract 1783.

An experiment was reported in which the range 3–25 mc was swept and backscatter from distances up to 3,500 km was recorded with a modified vertical-incidence recorder.

(41) R. Silberstein, "Sweep-frequency (3–25 mc/s) backscatter," presented at URSI-IRE Meeting, Nat'l. Bur. of Stds., Washington, D. C.; April, 1953.

Movements of the Ionosphere

A special report on this subject prepared by URSI is of special significance. It is available from the General Secretariat of URSI, 42 rue des Minimes, Brussels. Movements in the ionosphere, or ionospheric winds, were being studied by an increasing number of methods: deductions from $h'-f$ records, comparison of fading records, drift of meteor trails, scintillation of radio stars, and observations of visible aurora. The principal cause is solar and is due to thermal action and to gravitational action enhanced by a 12-hour resonance. Lunar effects are thought to be entirely gravitational and very much less than solar effects. This study goes far in explaining ionospheric effects that have long been held anomalous.

(42) "Tidal phenomena in the ionosphere," URSI *Spec. Rpt. 2*, prepared by special sub-commission: D. F. Martyn (chairman), W. J. G. Beynon, S. Chapman, J. Egedal, A. G. McNish, K. Weekes.

(43) A. B. Meinel, "Systematic upper atmospheric motions during auroral displays," presented at joint URSI-IRE Meeting, Ottawa, Can.; October, 1953.

Ionospheric Storms

The global morphology of disturbances of fF2 was discussed. The quotient of monthly averages of disturbed values to quiet values for each local hour of the day was plotted and, for many individual storms, the quotient of the disturbed values of critical frequency to the monthly mean value for that hour was plotted. The first method gave an *average* description with a general emphasis on the weaker storms, while the second method gave an *actual* description of individual storms.

Other workers have studied the diurnal and storm-time variations of ionospheric storms. The diurnal variations are shown to be highly complex, with significant differences appearing in different seasons and at different levels of activity. The storm-time variations of foF2 and absolute horizontal magnetic force are found to be closely linked statistically.

(44) E. V. Appleton and W. R. Piggott, "Ionospheric storms and the geomagnetic anomaly in the F2-layer," *Jour. Atmos. Terr. Phys.* (Correspondence), vol. 3, pp. 121–123; February, 1953. DSIR abstract 2308.

(45) D. F. Martyn, "Geo-morphology of F2-region ionospheric storms," *Nature*, vol. 171, pp. 14–16; January, 1953. DSIR abstract 1673. (See discussion in last year's review.) See also, "The morphology of the ionospheric variations associated with magnetic disturbance; Part I: Variations at moderately low latitudes," *Proc. Roy. Soc.*, vol. 218A, pp. 1–18; June, 1953. DSIR abstract 3301.

(46) R. P. W. Lewis and D. H. McIntosh, "Diurnal and storm-time variations of geomagnetic and ionospheric disturbance," *Jour. Atmos. Terr. Phys.*, vol. 3, pp. 186–193; May, 1953. DSIR abstract 3300.

Auroral Propagation

Intense effort was made to verify or modify as necessary Martyn's theory of the aurora. The general features of the theory seem to be correct, but there is a clamant need for information on the fine structure of the streams of charged particles impinging on the atmosphere of the earth.

The interpretation of vhf radio reflections from the aurora is now centered about three theses. American workers held that reflections arise by scattering from numerous auroral trails of ionization, somewhat like meteor trails, having the magnetic zenith as radiant. The aggregate of Doppler whistles associated with the incoming velocity of auroral particles may explain the higher-frequency components of the observed fading. The lower-frequency components of fading are about ten times greater than for a quiet atmosphere and are presumably due to the wind-like motion of the trails. It was found that radar echoes were obtained only when the antenna was directed to within a few degrees of normal to the rays, and it was concluded that there is a striking aspect sensitivity. Auroral echoes at 2.4 mc are obtained at ranges up to 1,000 km. As the auroral display develops, the range decreases to that of the virtual height of the F region where the echoes appear to combine to form spread-F echoes. This coincidence appears to rule out interpretation of echoes at this frequency in terms of reflection perpendicular to auroral trails and suggests an advancing front of irregularities moving southward in the F region at a speed usually of the order of 1,000 km/hour but sometimes as low as 100 km/hour. The arrival of 50 mc signals in Ithaca, New York from Cedar Rapids, Iowa by auroral transmission is from a northwesterly direction.

Canadian workers obtained radar echoes at vhf but not at 3,000 mc. The vhf echoes were obtained when the aurora exhibited ray structure. It was held that directly beneath the reflection region there is a region of high absorption and that only at angles less than 15 degrees above the horizon will the path of the radar ray pass over this absorption region and reach the reflecting region.

Norwegian workers interpreted echoes returned to the transmitter site from auroral ionization as being due to backscatter from the ground via the Es layer commonly found to exist during periods of auroral activity.

(47) H. G. Booker, C. W. Gartlein, and B. Nicols, "An interpretation of radio reflections from the aurora," presented at the Joint URSI-IRE Meeting, Ottawa, Can.; October, 1953. Also Cornell Univ. *Res. Rpt.* EE 169, August, 1953

Radio Studies of Meteoric Ionization

Measurements were made of the length of ionized meteor trails, and evidence was produced of extended-range radio transmissions by oblique reflection from meteoric ionization. Techniques were worked out for ionospheric wind analysis using meteoric echo measurements, and a theoretical investigation of the strength of meteoric echoes from dense columns was made.

A distribution of the occurrence of meteoric ionization with height was obtained, and the dependence of the height of ionization on the size and velocity of the meteoric particles was established. Abnormally long-enduring echoes were studied and the effects of radar sensitivity and radio wavelength on echo durations were investigated.

The measurement of meteoric velocities and radiants by radio-echo techniques was continued a theory of "head echoes" and stratified echoes in terms of discontinuities and sharp irregularities in the electron concentration along the trail was worked out. Measurements of echo amplitude versus time for electric polarization both transverse and parallel to the meteor trail were shown to be in good agreement with theory. A detailed interpretation of radio echoes from meteoric ionization in terms of the properties of the incident meteors, of the atmosphere in the meteor ionization region, and of the processes connected with the production and decay of the ionization was published.

(48) L. A. Manning, "Meteoroc radio echoes," Trans. I.R.E., PGAP (in press).
(49) D. W. R. McKinley, "Effect of radar sensitivity on meteor echo durations," *Canadian Jour. Phys.*, vol. 31, p. 758; 1953.
(50) T. R. Kaiser, "Radio echo studies of meteor ionization," *Advances in Physics*, vol. 2, p. 495; 1953.
(51) B. W. Currie, P. A. Forsyth, and F. E. Vawter, "Radio reflections from aurora," *Jour. Geophys. Res.*, vol. 58, pp. 179–200; June, 1953. DSIR abstract 3308.
(52) L. Harang and B. Landmark, "Radio echoes observed during aurora and terrestrial magnetic storms using 35 and 74 mc/s waves simultaneously," *Nature*, vol. 171, pp. 1017–1018; June, 1953. DSIR abstract 2976.

Failure to detect auroral radio noise at 3,000 mc, observed in 1949 was attributed to the decrease of the intensity of auroral displays with decreasing sunspot activity.

(53) R. P. Chapman and B. W. Currie, "Radio noise from aurora," *Jour. Geophys. Res.*, vol. 58, pp. 363–367; September, 1953.

Miscellaneous

Another atlas of $h'-f$ records was issued which will be of assistance in the interpretation of high latitude observations.

A book on ionospheric physics was published in German and its application to radio science and engineering should not be overlooked.

(54) G. H. Hanson, E. L. Hagg, and D. Fowle, "The interpretation of ionospheric records," Canadian Defense Research Board, Radio Phys. Lab. Rpt. R-2; May, 1953.
(55) K. Rawer, "Die Ionosphäre—ihre Bedeutung für Geophysik und Radioverkehr," P. Noordhoff N. V., Groningen (Holland).

Tropospheric Propagation

Measurements Well Beyond the Horizon: Observations over ten years ago began to indicate that vhf fields at distances of several hundred miles beyond the horizon, though weak and fading, were very much stronger than was indicated by classical theory of propagation around the earth bulge. Measurements of distant vhf tropospheric fields which were recently reported from England, France, and Germany, added weight to the theory that this type of "tropospheric scatter" propagation is omnipresent. Statistical distribution of fields over a year's time were reported for 60 and 68 mc multichannel phone links on a 213 km path from Berlin to the Harz mountains. Median fields measured over long time intervals out to distances of 450 km on frequencies in the range 41 to 94 mc were published in Great Britain, in connection with the problem of estimating required separation between television stations. In France, measurements over an eight month period at 100 mc at distances out to 700 km emphasized the apparent differences in the observations at longest ranges compared to those made between terminals only moderately nonoptical. The French observers noted that the fading characteristics of the weak fields at the longer distances had no apparent affect on the modulation of a sound broadcast channel so long as sufficient margin of signal over noise is maintained. Measurements at 3,675 mc of fields over paths approximately 130 miles long between Miami and Key West were in substantial agreement with earlier observations over much rougher New England terrain.

(56) H. Schröder, Statistics of propagation conditions for five meter waves at ranges beyond optical sight, (in German), *Frequenz*, vol. 6, pp. 20–25; January, 1952.
(57) J. A. Saxton, "Long distance propagation in relation to television in the United Kingdom," *Proc. IEE* (London), vol. 99, part 3A, pp. 294–299; 1952.
(58) B. Sadoun, "Propagation of meter waves to great distances," (in French), *Ann. Telecomm.*, vol. 8, pp. 299–308; August–September, 1953.
(59) R. L. Robbins, "Measurement of path loss between Miami and Key West at 3675 Mc," Trans. I.R.E. PGAP, vol. AP-1, pp. 5–9; July, 1953.

A recent article paid appropriate tribute to Marconi's three great propagation discoveries, among which was useful transmission of vhf waves beyond line of sight distances.

(60) E. H. Armstrong, "The spirit of discovery. An appreciation of the work of Marconi," *Elec. Eng.*, vol. 72, pp. 670–676; August, 1953.
(61) G. Marconi, "Radio communications by means of very short electric waves," Proc. Royal Institution of Great Britain, vol. 27, pp. 509–544; December, 1932.

Explanations for Scatter-Type Tropospheric Fields: The three most discussed mechanisms: (a) scattering by turbulence, (b) scattering in the atmosphere treated as a dielectric layer, and (c) scattering connected with nonstandard layers both high and low in the troposphere were the subjects of several papers relating to transmission beyond the horizon. Research related to the turbulence hypothesis centered on the use of the airborne microwave refractometer to get measurements aloft of the index-of-refraction fluctuations, from which the scattering is one possible cause of nonoptical fields larger than expected. Calculations were made of the fields to be expected statistically from the turbulence measured on a number of flights with a refractometer in the United States. Some calculations were made of the intensity and scale of turbulence aloft which it would be necessary to assume to explain long distance 100 and 1,047 mc observations in Colorado.

(62) C. M. Crain, A. P. Deam, and J. R. Gerhardt, "Measurement of tropospheric index-of-refraction fluctuations and profiles," Proc. I.R.E., vol. 41, pp. 284–290; February, 1953.
(63) C. E. von Rosenberg, C. M. Crain, and A. W. Straiton, "Atmospheric refractive-index fluctuations as recorded by an airborne microwave refractometer," Trans. I.R.E. (in press).
(64) W. E. Gordon, "Radio scattering from a turbulent elevated layer," Proc. of the Conference on Radio Meteorology, Bureau of Engineering Research, University of Texas, Austin, Texas; November, 1953.
(65) J. W. Herbstreit, K. A. Norton, P. L. Rice, and G. E. Schafer, "Radio wave scattering in tropospheric propagation," Convention Record of the I.R.E., part 2, pp. 85–93; 1953.

The low attenuation rate well beyond the horizon at frequencies above 50 mc, as well as the omnipresence of the fields, have been interpreted previously as evidence of mode-type propagation around a curved earth surmounted by a linearly tapered layer of air dielectric with a uniform standard gradient. Criticism of this model centers on the discontinuity of index gradient at the top of the atmosphere, above which the air density was taken to be zero, although in the real atmosphere this taper to vacuum at great heights must be continuous. Therefore, renewed attention was given to the calculation of vhf fields scattered from high-level inversions, which were shown by microwave-refractometer flights to be more prevalent and important than was once supposed.

(66) T. J. Carroll and R. M. Ring, "Important modes in the troposphere treated as a linearly graded layer of dielectric," Proc. Conf. Radio Met., 1953.
(67) F. H. Northover, "The anomalous propagation of the longer VHF waves," Proc. Conf. on Radio Met., 1953.

Propagation within the Horizon: A symposium on propagation over optical paths was held in San Diego, Calif. in the spring of 1953. A text-book appeared in which much space is devoted to field intensity calculations over optical paths, and which also contains a comparison of experimental observations on propagation over optical paths at uhf, with these calculations.

(68) W. C. Hoffman, "The 1953 symposium on tropospheric wave propagation within the horizon at the U. S. Navy Electronics Laboratory," TRANS. I.R.E. PGAP, vol. AP-1, pp. 28–30; July, 1953.
(69) H. R. Reed and C. M. Russell, "Ultra High Frequency Propagation," John Wiley and Sons, Inc., New York, N. Y.; 1953.
(70) "Symposium on Tropospheric Radio Wave Propagation within the Horizon," Report No. 409, U. S. Navy Electronics Laboratory, San Diego, Calif.; September, 1953.

Meteorology of Ducts: Renewed interest was shown in the study of how the micrometeorological state of the atmosphere occasionally produces superrefracting layers which may be forecast to the extent that the relevant meteorological parameters can be predicted. Easily available synoptic meteorological data were studied in correlation with radio measurements.

(71) L. J. Anderson and E. E. Gossard, "Prediction of the nocturnal duct and its effect on UHF," PROC. I.R.E., vol. 41, pp. 135–139; January, 1953.
(72) F. R. Bellaire and W. A. Arvola, "Prediction of diurnal field strength patterns by synoptic methods," Proc. Conf. Radio Met., 1953.
(73) C. W. Spencer, "Radio-wave propagation at 89 mc/sec. in relation to synoptic conditions," *Meteorological Mag.*, vol. 81, pp. 206–212; 1952.
(74) K. H. Jehn and R. C. Staley, "Correlation of 100 mc radio propagation with certain meteorological variables," *Jour. Atmospheric and Terrestrial Phys.*, vol. 3, pp. 163–171; April, 1953.

Radar Meteorology: Recent work on meteorological investigations and examination of microwave scattering in the atmosphere was discussed at the Fourth Annual Radar Weather Conference.

(75) *Proc. Conf. Radio Met.;* November, 1953.

Radar measurements of the formation and growth of snowflakes and raindrops led to increased understanding of the physics of precipitation.

(76) S. E. Reynolds, "Cloud physics—a review," *Proc. Conf. Radio Met.;* 1953.
(76A) R. Wexler and P. M. Austin, "Radar signal intensity from different levels in continuous precipitation," *Proc. Conf. Radio Met.;* 1953.
(77) J. S. Marshall, "Precipitation trajectories and patterns," *Jour. Met.*, vol. 10, pp. 25–29; 1953.
(78) D. Atlas and S. Bartnoff, "Cloud visibility, radar reflectivity, and drop-size distribution," *Jour. Met.*, vol. 10, pp. 143–148; 1953.

Radar can be used for measuring rainfall and has limited use for fog observation. Attenuation effects and the limiting precision of such measurements were examined.

(79) W. Hitschfeld, "Measurement and detection of rainfall by radar at attenuating wavelengths," *Proc. Conf. Radio Met.;* 1953.
(80) R. J. Donaldson, D. Atlas, W. H. Paulsen, R. M. Cunningham, and A. C. Chmela, "Quantitative 1.25 cm observations of rain and fog," *Proc. Conf. Radio Met.;* 1953.
(81) G. E. Stout and J. C. Neill, "Utility of radar in measuring a real rainfall," *Bull. Amer. Met. Soc.*, vol. 34, pp. 21–27; January, 1953.

The relation between the fluctuating character of weather echoes and the turbulence within the rain or snow creating the echoes received further study. Autocorrelation techniques were found useful for refined measurements of the distribution of gust velocities and may serve to calibrate a simpler device as a sort of radar turbulence meter.

(82) A. Fleisher, "The radar as a turbulence sensing probe," *Proc. Conf. Radio Met.;* 1953.

The present status of quantitative meteorological measurements by radar was reviewed.

(83) P. M. Austin, "Information obtainable from quantitative observation of radar echoes from precipitation," *Proc. Conf. Radio Met.;* 1953.

Progress continued toward increasing the value of radar observations to the weather forecaster.

(84) M. G. H. Ligda, "The use of radar storm observations for weather forecasting," *Proc. Conf. Radio Met.;* 1953.
(85) J. Lugeon, "Pulse observation of wind by radio, 'Echosonde' without responder," *Compt. Rend. Acad. Sci.* (*Paris*), vol. 236, pp. 2426–2428; June, 1953.

Though it was not determined conclusively that tornadoes can be identified by radar, radar can be useful to any tornado-warning service. A co-ordinated tornado research program using both radar and "sferics" was evolved.

(86) G. E. Stout, "Radar tracks an Illinois tornado," *Weatherwise*, vol. 6, pp. 76–77; June, 1953.

A careful study of the type of radar echoes called "angels" gave strong credence to the atmospheric discontinuity theory, and temperature- and moisture-discontinuity theory was further substantiated by observation of a wall of "angels" on an advancing sea-breeze front.

(87) V. G. Plank, "A meteorological study of angles at 1.25 cm," *Proc. Conf. Radio Met.;* 1953.
(88) D. Atlas, W. H. Paulsen, R. J. Donaldson, A. C. Chmela, and V. G. Plank, "Observations of the sea breeze by 1.25 cm radar," *Proc. Conf. Radio Met.;* 1953.

Radio Astronomy

Solar Radio Waves: Considerable effort was directed toward determining the distribution of radio "brightness" across the solar disk. A new antenna system having a very high resolving power was constructed in Australia for use at 21 centimeters. It consists of 32 identical paraboloidal reflectors, each six feet in diameter, spaced at equal intervals over a distance of about 700 feet along an east-west line. The directional diagram of this system is characterized by a succession of narrow lobes which, in the east-west direction, are only three minutes of arc in width and are separated from each other by 1.7 degrees. As the sun is scanned, each lobe yields a separate determination of the distribution of the radiation across the disk. A comparison of radio brightness showed that peaks of radio emission tended to occur in regions occupied or previously occupied by sunspots. The day-to-day movement of these peaks across the disk was readily followed. When such peaks were disregarded, the existence of a limb-brightening of the "quiet" component of the 21-centimeter solar radiation became apparent.

(89) W. N. Christiansen, "A high-resolution aerial for radio astronomy," *Nature* (*London*), vol. 171, pp. 831–833; May, 1953.
(90) W. N. Christiansen and J. A. Warburton, "The distribution of radio brightness over the solar disk at a wavelength of 21 centimetres, I. A new highly directional aerial system," *Aust. Jour. Phys.*, vol. 6, pp. 190–202; June, 1953.

The radio size and shape of the sun's disk was measured at a wavelength of 1.4 meters in England. An interferometer consisting of two antennas having variable separation was used. The radio shape of the sun's disk was indicated to be approximately elliptical, the equatorial diameter exceeding the polar diameter by about 25 per cent. The average radial extent of the disk, measured over a seven-month period, showed a slow decrease which was correlated with a decrease in the average intensity of the green coronal spectrum line at a wavelength of 5,303 angstroms.

(91) "Meeting of the Royal Astronomical Society," *Observatory*, vol. 73, pp. 97–103; June, 1953.
(92) P. A. O'Brien, "The radio 'brightness' across the solar disk at a wavelength of 1.4 metres and its relation to the coronal line emission," *Observatory*, vol. 73, pp. 106–109; June, 1953.

Statistical relations between Solar radio emission was compared statistically with sunspot and flare phenomena. Information concerning the directivity of the sunspot-dependent component of radio-frequency radiation was deduced by comparing levels of solar radio emission with data on the positions of sunspots on the disk.

The 200-mc solar radiation observed during 194 flares which occurred between July, 1948 and December, 1950 was analyzed. Distinctive radio events accompanied seventy-eight per cent of the flares. Abrupt events, such as bursts of radio emission, tended to occur at about the same time as the commencements of the associated flares, whereas the more gradual flare-related changes in radio emission, such as noise storms and rises in base level, tended to occur at or after the times of flare maxima. An association of strong bursts of radio emission with high-velocity ejections of material at the times of onset of certain flares was suggested.

(93) M. Jorand, "Le rayonnement radioélectrique des taches solaires sur 160 mc/sec de 1948 à 1951," *Ann. d'Astrophys.* vol. 16, pp. 151–161; May–June, 1953.
(94) T. Takakura, "A method of analysis of the directivity of solar radio emission from sunspots," *Nature* (*London*), vol. 171, p. 445; March, 1953.
(95) H. W. Dodson, E. R. Hedeman, and L. Owren, "Solar flares and associated 200 mc/sec radiation," *Astrophys. Jour.*, vol. 118, pp. 169–196; September, 1953.
(96) H. W. Dodson, E. R. Hedeman, and J. Chamberlain, "Ejection of hydrogen and ionized calcium atoms with high velocity at the time of solar flares," *Astrophys. Jour.*, vol. 117, pp. 66–72; January, 1953.

Two additional isolated occurrences were noteworthy. An ascending prominence was accompanied by bursts of radio emission at several frequencies between 62 and 600 mc, and a rare instance of absorption of 2,800-mc solar radiation was recorded during the post-maximum stage of a flare.

(97) A. K. Das, K. Sethumadhaven, and R. D. Davies, "Eruptive prominence of February 26, 1953, and associated radio noise-burst," *Nature* (*London*), vol. 172, pp. 446–448; September, 1953.
(98) A. E. Covington and H. W. Dodson, "Absorption of 10.7-centimetre solar radiation during flare of May 19, 1951," *Jour. Roy. Astr. Soc.* (*Canada*), vol. 47, pp. 207–211; September–October, 1953.

Observational evidence of second harmonics in the spectra of two radio outbursts was obtained with a new instrument capable of rapidly scanning from 38 to 220 mc.

(99) J. P. Wild, J. D. Murray, and W. C. Rowe, "Evidence of harmonics in the spectrum of a solar radio outburst," *Nature* (*London*), vol. 172, pp. 533–534; September, 1953.

Arguments favored interpreting certain of the sun's high-intensity radio-frequency phenomena such as noise storms, bursts, and outbursts in terms of ordered motions of electrons.

(100) J. H. Piddington, "Thermal theories of the high-intensity components of solar radio-frequency radiation," *Proc. Phys. Soc.* (*London*), ser. B, vol. 66, pp. 97–104; February, 1953.
(101) H. K. Sen, "Solar 'enhanced radiation' and plasma oscillations," *Phys. Rev.*, vol. 88, pp. 816–822; November, 1952.
(102) H. K. Sen, "An estimate of the density of motion of solar material from observed characteristics of solar radio outbursts," *Aust. Jour. Phys.*, vol. 6, pp. 67–72; March, 1953.

The expected slow decrease in the level of the radio emission from the quiet sun during the decline from sunspot maximum to minimum, calculated on the basis of assumptions concerning the dependence of electron density on height in the solar atmosphere and on phase in the sunspot cycle was confirmed by data obtained at 2,800 mc. At various frequencies between 600 and 9,400 mc, the daily level of solar radiation varied in a manner consistent with a hypothesis that the corona is maintained by the formation of regions of high temperature and high pressure above sunspots. An observed limb darkening of the 2,800-mc solar radiation originating in "coronal condensations" was interpreted as an effect of the structures of these emissive regions.

(103) T. Hatanaka and F. Moriyama, "A note on the long-period variation in the radio-frequency radiation from the quiet sun," *Pub. Astr. Soc. Japan*, vol. 4, pp. 145–151; 1953.
(104) J. H. Piddington and R. D. Davies, "Origin of the solar corona," *Nature* (*London*), vol. 171, pp. 692–693; April, 1953.
(105) M. Waldmeier, "Die randverdunkelung der radiofrequenten sonnenstrahlung bei $\lambda=10.7$ cm," *Zeit. Astrophys.*, vol. 32, 124; 1953.

Galactic Radio Waves: Investigations of the distribution of the intensity of the general galactic radiation were carried out at frequencies of 158.5 and 250 mc. The observations at the lower frequency were made with the 220-foot paraboloid at Manchester, England. This instrument has a beam width to half-power points of only 2 degrees. Contour lines representing the intensity distribution were derived for the portion of the sky between galactic longitudes 40 degrees and 130 degrees and latitudes +14 degrees and −14 degrees. They revealed the presence of several localized sources that had not appeared in previous surveys made with less directional radio telescopes or with interferometers.

Observations at 250 mc, at Ohio State University, were made with another type of radio telescope, consisting of an array of 48 right-handed helical beam antennas mounted on a steel ground screen rotatable about an east-west axis so as to point to the meridian at any chosen declination between −40 degrees and +90 degrees. Its beam width between half-power points is about 17 degrees in the north-south direction and 1.2 degrees in the east-west direction. A narrow, low-intensity maximum whose ridge line is near right ascension 13^h and extends for at least 15 degrees on either side of the celestial equator was found. Its source was tentatively identified as the local supergalaxy.

(106) R. H. Brown and C. Hazard, "A radio survey of the Milky Way in Cygnus, Cassiopeia and Perseus," *Mon. Not. R. Astr. Soc.*, vol. 133, pp. 109–122; 1953.
(107) J. D. Kraus and E. Ksiazek, "New techniques in radio astronomy," *Electronics*, vol. 26, pp. 148–152; September, 1953.
(108) J. D. Kraus and H. C. Ko, "Radio radiation from the supergalaxy," *Nature* (*London*), vol. 172, pp. 538–539; September, 1953.

Observed contour lines of galactic radio emission were analyzed and new models were constructed to represent them as the resultant of: (1) radiation from localized sources in the galaxy, (2) radiation from ionized interstellar gas, and (3) an isotropic component probably of extragalactic origin.

(109) R. H. Brown and C. Hazard, "A model of radio-frequency radiation from the galaxy," *Phil. Mag.*, vol. 44, pp. 939–963; September, 1953.
(110) S. P. Wyatt, Jr., "A radio model of the galaxy," *Astrophys. Jour.*, vol. 118, pp. 304–313; September, 1953.

Two different techniques were applied to the direct observation of the radio-frequency radiation of interstellar hydrogen. The first was aimed at the detection of regions of ionized hydrogen. Because of their strong concentration to the galactic plane, such regions can be expected to influence the intensity distribution of the general galactic radiation only within a degree or two of the galactic equator. Calculations showed that at frequencies lower than 60 mc they should absorb more radiation than they emit, while at higher frequencies their emission should predominate. Interferometric observations on frequencies of 81.5 and 210 mc revealed the predicted presence of a narrow bright strip along the galactic equator.

Clouds of neutral interstellar hydrogen were investigated by observation of their spectrum line emission at 1,420 mc. Numerous profiles of this line, which results from a hyperfine-structure transition, were obtained by Dutch scientists using a 7.5-meter paraboloid with a beam width of 3 degrees. Separate peaks in a given profile were attributed to individual clouds through which the line of sight penetrated, and the radial velocities of the clouds were deduced by interpreting the measured frequency shifts as Doppler displacements. The distances of the clouds were then calculated on the assumption that their observed motions are due primarily to differential galactic rotation. Such analyses indicated that in the regions so far explored the clouds are concentrated in narrow, curved bands which are reasonably interpreted as spiral arms. This radio-frequency method of investigating the structure of the galaxy is extremely important because it yields information concerning distant regions which have hitherto not been available for observation; it has already enabled one spiral arm to be traced well into the half of the galaxy on the opposite side of the galactic center from the sun.

(111) P. A. G. Scheuer and M. Ryle, "An investigation of the H II regions by a radio method," *Mon. Not. R. Astr. Soc.*, vol. 113, pp. 3–17; 1953.
(112) W. N. Christiansen and J. V. Hindman, "A preliminary survey of 1,420 Mc/s line emission from galactic hydrogen," *Aust. Jour. Sci. Res.*, ser. A, vol. 5, pp. 437–455; September, 1952.
(113) H. C. van de Hulst, "The galaxy explored by radio waves," *Observatory*, vol. 73, pp. 129–139; August, 1953.

Hydrogen radiation at 1,420 mc was also detected from our two nearest extragalactic neighbors, the Magellanic Clouds.

In both hemispheres, interferometric methods were applied to the further study of discrete sources of radio emission. The identifications of the strong sources in Centaurus, Virgo, and Taurus with NGC 5128, NGC 4486, and the Crab Nebula, respectively were strengthened both by new determinations of their positions and by measurements of their angular diameters. The strong sources in Cassiopeia and Cygnus were studied in detail. Their shapes as well as their angular sizes were investigated with a new interferometer in which high resolution was achieved by means of a long base line containing a radio link. The Cassiopeia source was found to be roughly symmetrical in shape, the Cygnus source highly unsymmetrical. The equivalent angular size of the latter ranged from 35 inches to 2 feet 10 inches when observed from base lines of different orientations. The distribution of radio "brightness" across each of these two sources was also investigated.

(114) R. H. Brown, R. C. Jennison, M. K. Das Gupta, B. Y. Mills, and F. G. Smith, "Apparent angular sizes of discrete radio sources," *Nature* (*London*), vol. 170, pp. 1061–1065; December, 1952.
(115) B. Y. Mills, "The positions of six discrete sources of cosmic radio radiation," *Aust. Jour. Sci. Res.*, ser. A, vol. 5, pp. 456–463; September, 1952.

(116) F. G. Smith, "The measurement of the angular diameter of radio stars," *Proc. Phys. Soc.* (*London*), ser. B, vol. 65, pp. 971–980; December, 1952.

Interferometric methods for measuring the positions of discrete sources of small angular extent were compared and inherent errors analyzed.

(117) F. G. Smith, "The determination of the position of a radio star," *Mon. Not. R. Astr. Soc.*, vol. 112, pp. 497–513; 1952.

New observational data obtained with the 220-foot paraboloid supported the conclusion that the intense discrete sources are concentrated to the galactic plane.

(118) R. H. Brown and C. Hazard, "A survey of 23 localized radio sources in the northern hemisphere," *Mon. Not. R. Astr. Soc.*, vol. 113, pp. 123–133; 1953.

The theoretical interpretation of radio emission from the Crab Nebula was discussed. Calculations indicated that thermal emission can account for only about one-ninetieth of the observed flux at 100 mc. However, a large increase of the rate of radiation may be expected if there is appreciable charge separation in the source. The emission of radio-frequency radiation from the Orion Nebula was predicted from theoretical considerations, but attempts to detect this nebula at a frequency of 210 mc showed that its flux is not greater than 9×10^{-25} watts per square meter per cycle per second.

(119) F. D. Kahn, "On some possible mechanisms of radio stars. I. The Crab Nebula," *Mon. Not. R. Astr. Soc.*, vol. 112, pp. 514–517; 1952.
(120) J. L. Greenstein and R. Minkowski, "The Crab Nebula as a radio source," *Astrophys. Jour.*, vol. 118, pp. 1–15; July, 1953.
(121) F. Hoyle, "Cosmic origin of radiation at radio frequencies," *Nature* (*London*), vol. 172, pp. 296–297; August, 1953.
(122) J. E. Baldwin, "A search for radio emission from the Orion Nebula," *Observatory*, vol. 73, pp. 155–157; August, 1953.

The widespread interest and activity in the field of radio astronomy was reflected in the many new and improved instruments under construction or recently been put into operation. Among these are two of particularly large dimensions. A giant steerable radio telescope with a parabolic reflector 250 feet in diameter is being constructed at the Jodrell Bank Experimental Station. A new interferometer employing four antennas, each of which is a 100-meter-long cylindrical section of a paraboloid, was put in operation at the Cavendish Laboratory. The antennas are arranged in pairs that are separated by a distance of about 600 meters. This interferometer is very much more sensitive than its predecessors and has already revealed the existence of numerous discrete sources that were previously undetectable.

Industrial Electronics

Dielectrics: Insulating materials continue to increase in number and variety of properties. Synthetic plastic insulation is a major factor in the communications industry in producing components and in manufacturing instruments and appliances. The use of synthetic rubbers and plastics has continued to gain on natural rubber for insulating use. Established plastics are finding expanding applications in the industrial market.

Insulating materials are required to give satisfactory service under a wide variety of environmental conditions. Recognition of this fact has prompted many investigations into the effect of temperature, humidity, heat, and surface contamination on the insulating characteristics of materials. These trends were apparent at the annual meeting of the conference on Electrical Insulation of the National Research Council, October 19–21, 1953. Electrical degradation and breakdown, high-temperature problems and proposals for functional-temperature classifications related to service conditions were among the topics receiving considerable emphasis. Modifications of existing plastics and broadening their field of application continued to take precedence over development of chemically new polymer types. Search for insulating materials that will operate with stability at high temperatures remains on the list of requirements, especially for military applications. Considerable high-temperature progress has been made but ultimate goals do not appear to have been achieved to date.

The exploitation of nonlinear dielectrics, the measurement of relaxation times, and the development of dielectric materials with better temperature characteristics received the greatest attention during the past year.

Several barium-titanate bodies were developed for use as ferro-electric storage elements. Practically flat sheets a few mils thick were produced with remarkable uniformity in respect to abundance and spacing of the small square-shaped single crystals. The slight scattered porosity of these sheets does not appear detrimental for this use.

Ceramics, high polymers, and thin organic films that have high dielectric constants and can be used at high temperatures were developed.

Comparison of the relaxation times derived from ultrasonic and dielectric measurements showed very close agreement, indicating that the mechanisms of both phenomena were the same. In most of this work oils, colloids, and glycerine were used.

Measurements showed that the dielectric properties of nonconducting colloidal particles, as well as iron particles suspended in oil, responds rapidly not only to acceleration but also to deceleration of shear rate. This threw new light on the flow properties and the mechanism of motion of gels.

With a view toward improving radioactive current and voltage sources, some interesting work was done on the conductivity induced in dielectric materials by radioactivity.

A compendium of the literature on dielectrics for 1952 appears in the Vol. XVI of the Digest of the Literature on Dielectrics published by the National Academy of Sciences—National Research Council.

It offers a wealth of information on: instrumentation and measurements; molecular and ionic interactions in dielectrics; the breakdown of dielectrics, ferroelectric and piezoelectric materials; insulating plastics; films and ceramics; semi-conducting materials; ferromagnetic semi-conductors; and radiation sensitive and luminescent materials.

Induction and Dielectric Heating: A major achievement in induction heating was the successful attachment of rims to twenty-inch cathode-ray tubes. The resulting seal is vacuum tight and is achieved with one "shot" of five-half-cycles of a sixty-cycle wave. The surge peak power employed is two hundred kilowatts.

Magnetic Amplifiers: Because of the advantages of solid-state components in applications where reliability is of primary importance, magnetic amplifiers were used increasingly in industry.

(123) W. F. Horton, "Magnetic amplifiers for industry," *Radio and Telev. News, Radio-Electronic Eng. Sec.*, vol. 48, pp. 10–12; November, 1952.
(124) W. Schmidt, "Dynamic characteristics of transductors or magnetic amplifiers," *Arch. Elect. Übertragung*, vol. 7, pp. 249–255; May, 1953.
(125) W. A. Geyger, "Magnetic amplifiers of the selfbalancing potentiometer type," *Trans. AIEE*, pp. 383–395; January, 1953.
(126) R. H. Spencer, "Transistor-controlled magnetic amplifier," *Electronics*, vol. 26, pp. 136–140; August, 1953.
(127) G. M. Attura, "Magnetic amplifier with reset control," *Electronics*, vol. 26, pp. 161–163; June, 1953.
(128) A. G. Milnes, "Notes on Some Non-linear Magnetic Devices," Royal Aircraft Establishment, Fornborough, Tech. Note No. EL 51; May, 1953.
(129) A. G. Milnes, "Three-phase transductor circuits for magnetic amplifiers," *Proc. IEE* (*London*), vol. 99, pp. 336–357; December, 1952.
(130) A. G. Milnes and T. V. Vernon, "A saturable-core reference source for use with magnetic amplifiers," *Jour. Sci. Instr.*, vol. 30, pp. 135–138; April, 1953.
(131) W. A. Rote. "Magnetic-converter d-c amplifiers," *Electronics*, vol. 26, pp. 189–191; July, 1953.

An attempt was made to classify the basic circuit types of magnetic amplifiers in 1952.

(132) J. C. Miles, "Types of magnetic amplifiers—survey," *Trans. AIEE*, pp. 229–238; July, 1952.

Specialized uses of magnetic amplifiers and of the new nonmetallic magnetic materials included high-speed magnetic amplifiers as components for analog and digital computers.

(133) L. A. Finzi and R. A. Mathias, "Magnetic amplifiers for analytical operations," *Trans. AIEE*, pp. 455–461; September, 1953.
(134) R. A. Ramey, "The single-core magnetic amplifier as a computer element," *Trans. AIEE*, pp. 442–446; January, 1953.

Attempts were made to analyze the various types of magnetic amplifiers and to predict their performance in terms of core and rectifier properties.

(135) L. A. Finzi and G. F. Pittman, "Comparison of methods of analysis of magnetic amplifiers," *Proc. NEC* (*Chicago*), vol. 8, pp. 144–157; 1952.
(136) S. B. Batdorf and W. N. Johnson, "Self-saturating magnetic amplifiers," *Trans. AIEE*, pp. 223–227; July, 1953.
(137) L. Kühn, "Theory of the magnetic amplifier with free magnetization," *Frequenz*, vol. 7, pp. 89–94; April, 1953.
(138) H. F. Storm, "Saturable reactors with inductive d-c load," Part I: steady-state operation, *Trans. AIEE*, vol. 71, pp. 335–343; November, 1952; Part II: Transient response, *Trans. AIEE*, vol. 72, pp. 182–192; May, 1953.
(139) H. F. Storm, "Magnetic amplifiers with square-loop core materials," *Trans. AIEE*, vol. 72, pp. 629–640; November, 1953.

A wealth of information has been published regarding the development of new magnetic materials suitable for use in magnetic amplifiers and related devices. Intensive work was carried forward on magnetic amplifiers in the high-frequency range.

(140) J. L. Salpeter, "Developments in sintered magnetic materials," PROC. I.R.E., vol. 41, pp. 105–118; June, 1953.
(141) H. E. Hollmann, "High-frequency and low-frequency technology," *Arch. Elect. Übertragung*, vol. 6, pp. 434–440, 478–486, 520–531; October–December, 1952.
(142) Williams, Sherwood, Goertz, and Schnettler, "Stressed ferrites," *Trans. AIEE*, pp. 531–536; November, 1953.

Nonlinear Dielectrics: Little progress was reported in the field of dielectric amplifiers and in other uses of nonlinear dielectrics decreased.

(143) H. Urkowitz, "A ferroelectric amplifier," *Jour. Franklin Inst.*, vol. 254, pp. 517–530; December, 1952.
(144) B. G. Lewis, "Nonlinear condensers," *Radio and Telev. News, Radio-Electronic Eng. Sec.*, vol. 49, pp. 3–5; May, 1953.
(145) L. A. Pipes, "Analysis of series circuit with nonlinear capacitor," *Trans. AIEE*, pp. 238–244; July, 1953.

Automation: There was a rapid increase in activity in the field of automation, i.e. the fabrication of industrial products by an assembly of automatic machinery and conveyers, integrated by an over-all control system. The automotive industry invested heavily in automation, especially in connection with engine plants. The electronics industry is actively engaged in developing automatic assembly systems for its own products and in addition is vitally concerned with supplying the electronic controls necessary for any automatic system.

(146) J. Diebold, "Automation," D. Van Nostrand Co., Inc., New York, N. Y.; 1952.
(147) W. Pease, "An automatic machine tool," *Sci. Am.*, vol. 187, pp. 101–115; September, 1952.
(148) J. Y. Kaplan, "Automation of Machine Tools," ARMA Corp. Rep. No. 21 T 18, presented at the 21st annual meeting of the ASTE; March, 1953.
(149) C. Winkleman, "Ford's automated engine plant," *Factory Management and Maintenance;* December, 1952.
(150) "The automatic factory: Fortune round table," *Fortune*, vol. XLVIII, No. 4, p. 168; October, 1953.
(151) W. H. Hannahs and W. Serniuk, "Miniaturized amplifier designed for automatic assembly," *Electrical Manufacturing;* August, 1951.
(152) A. F. Murray, "Project 'Tinkertoy'—step toward automatic factory," *Tele-Tech.*, vol. 12, No. 11, p. 70; November, 1953.
(153) P. Klass, "Automatic factory near for electronics," *Aviation Week;* November, 1952.

Therapeutical Applications: The increased use of electronic measuring equipment in the practice of medicine is clearly indicated by the appearance of several devices for specific purposes. A sensitive respirometer was developed for the measurement of rapid changes in the metabolism of oxygen of a peripheral nerve.

Several other instrumentations deal with cardiac and brain measurements. An improved Cuvette densitometer for cardiac output determination by the dye-dilution method was devised. A micro glass electrode continuously records brain pH in situ. An analog device that can be used for the analysis of compartmental biological systems was developed. Electronic control circuits were applied to the mechanical heart and lung.

An attempt to provide an automatic electronically determined equivalent of a manual method of graphically analyzing differences between electro-encephalographic wave patterns from different parts of the head met with some degree of success.

The electromagnetic flowmeter was applied to industrial and biological problems, including the measurement of the flow of blood.

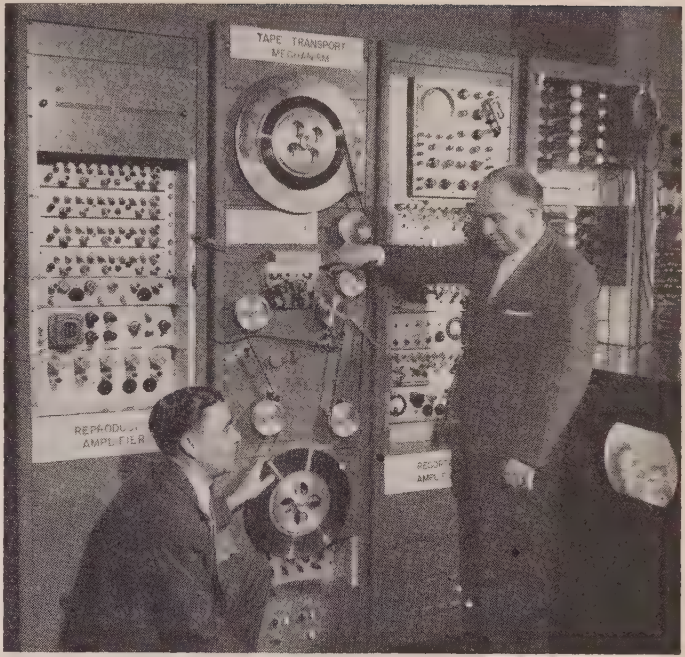
The characteristics of various types of vector-cardiograph leads were studied by analyzing their reciprocal fields in two-dimensional models of the human body. Ideally, the reciprocal fields should form a network that is orthogonally cartesian, in the region of the heart. Conventional leads do not approach the ideal form closely. Methods were developed for forming synthetic leads whose reciprocal fields approach the ideal closely.

An apparatus using the principle of the photoelectric measurement of intercepted light was developed for biological purposes with emphasis on its use in electrophoresis.

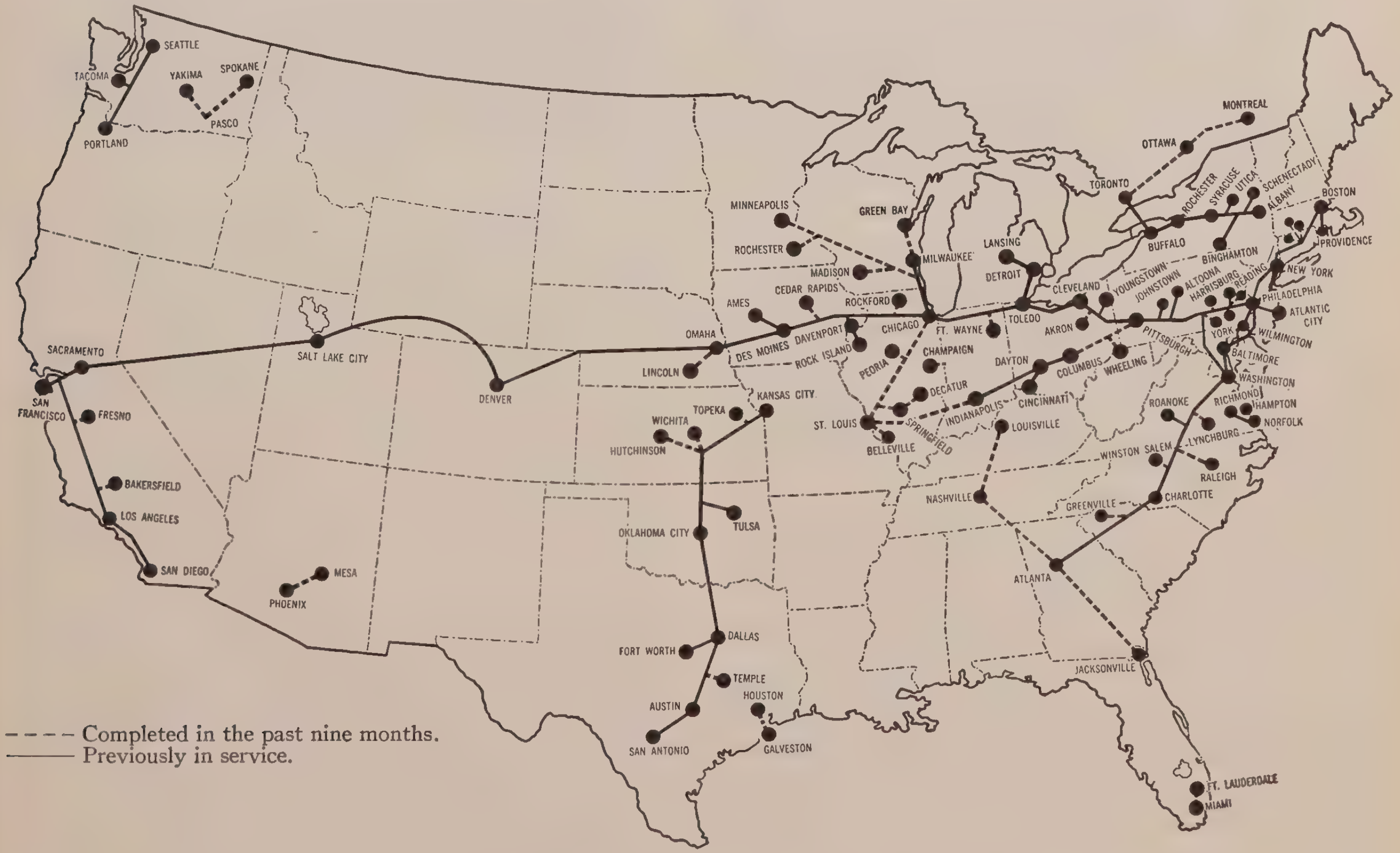
Television Broadcasting

In 1953, there was considerable advance in the field of television broadcasting in the United States. Of importance was the addition of 250 additional television stations of which many were uhf channels.

More than 3,000 miles of new radio relay routes were placed in operation by the Bell System. The total is now 10,300 miles. Television broadcasting was greatly expanded on a network basis. NTSC color television transmissions were made over microwave radio network facilities to Chicago and Los Angeles, evidencing future color-television network operations.


TAPE TRANSPORT MECHANISM
REPRODUCE AMPLIFIER

W. D. Houghton (*left*) and Dr. H. F. Olson with some of the apparatus used in the demonstration of video recording on magnetic tape. The setup shown, which is for color television, used five tracks on ½-inch tape. (RCA)


SEATTLE
TACOMA
YAKIMA
SPOKANE
PASCO
PORTLAND
SACRAMENTO
SAN FRANCISCO
FRESNO
BAKERSFIELD
LOS ANGELES
SAN DIEGO
SALT LAKE CITY
DENVER
PHOENIX
MESA
MINNEAPOLIS
ROCHESTER
MADISON
CEDAR RAPIDS
AMES
OMAHA
DES MOINES
DAVENPORT
ROCK ISLAND
LINCOLN
KANSAS CITY
TOPEKA
WICHITA
HUTCHINSON
TULSA
OKLAHOMA CITY
DALLAS
FORT WORTH
TEMPLE
HOUSTON
AUSTIN
SAN ANTONIO
GALVESTON
GREEN BAY
MILWAUKEE
ROCKFORD
CHICAGO
PEORIA
CHAMPAIGN
DECATUR
ST. LOUIS
BELLEVILLE
SPRINGFIELD
LANSING
DETROIT
TOLEDO
FT. WAYNE
INDIANAPOLIS
DAYTON
CINCINNATI
LOUISVILLE
NASHVILLE
COLUMBUS
CLEVELAND
AKRON
YOUNGSTOWN
JOHNSTOWN
PITTSBURGH
WHEELING
TORONTO
OTTAWA
MONTREAL
BUFFALO
ROCHESTER
SYRACUSE
UTICA
SCHENECTADY
ALBANY
BINGHAMTON
BOSTON
PROVIDENCE
NEW YORK
ALTOONA
HARRISBURG
READING
PHILADELPHIA
ATLANTIC CITY
YORK
WILMINGTON
BALTIMORE
WASHINGTON
RICHMOND
HAMPTON
NORFOLK
ROANOKE
LYNCHBURG
WINSTON SALEM
RALEIGH
CHARLOTTE
GREENVILLE
ATLANTA
JACKSONVILLE
FT. LAUDERDALE
MIAMI
---- Completed in the past nine months.
—— Previously in service.

Bell System Broad Band Relay Routes

Important demonstrations of magnetic tape recording of color and black-and-white television pictures, with sound, indicated future employment of this system of program recording and reproduction.

There was considerable activity in the field of television scanning of motion-picture film. A special improvement in the Vidicon film reproduction camera and in the operation of devices of this type was reported.

Studio equipment evidenced continued excellent design.

New techniques were described for the pickup and transmission of NTSC color signals in broadcasting, and in the development of high-gain amplifiers for high-power broadcast transmitters.

There were reports on high-power antenna operation, the operation of new types of studios, and broadcast installations.

(154) J. B. Dearing, H. E. Gihring, R. F. Guy, and F. G. Kear, "Multiple television and frequency-modulation transmitting antenna installation on the Empire State building," Proc. I.R.E., vol. 41; March, 1953.
(155) R. O'Brien, R. Monroe, and P. Fish, "CBS-Television's Hollywood Television City video, audio, and communication facilities." Presented at the 1953 IRE National Convention, New York, N. Y.; March, 1953.
(156) J. Epstein and D. W. Peterson, "An experimental study of wave propagation at 850 mc." Presented at the 1953 IRE National Convention, New York, N. Y.; March, 1953.
(157) F. J. Bingley, "A new television film scanner." Presented at the National Electronics Conference, Chicago, Illinois; September, 1953.
(158) H. N. Kozanowski, "Vidicon film reproduction cameras." Presented at the National Electronics Conference, Chicago, Illinois; September, 1953.
(159) J. F. Fisher, "Alignment of a monochrome TV transmitter for broadcasting NTSC color signals." Presented at the National Electronics Conference, Chicago, Illinois; September, 1953.
(160) A. R. Kramer and E. R. Kramer, "Building TV broadcast facilities for growth, flexibility, and economy." Presented at the 1953 IRE National Convention, New York, N. Y.; March, 1953.
(161) J. Ruston, "High-gain amplifiers for high power television transmitters." Presented at the 1953 IRE National Convention, New York, N. Y.; March, 1953.

Color Television: During 1953, the delegated panels of the National Television System Committee (NTSC) accomplished considerable progress in the industry-wide development of a compatible color television system.

The Federal Communications Commission approved the NTSC compatible color system on December 17, 1953, thereafter permitting broadcasting stations to transmit color television in accordance with the recently promulgated standards covering this type of transmission, and broadcast studios may originate color signals after the installation of the necessary studio and terminal equipment. About 80 television stations placed orders for color television transmitter- and studio-modification equipment.

A study was made of color-synchronizing methods and color-synchronization performance. Manufacturers were active in investigating the principles and development of color-television systems, leading to the provision of essential NTSC-color equipment.

Broadcasters engaged in color-television transmission over their networks, and programs were reproduced in color in some cities. Such transmission also enabled owners of monochrome receivers to see the color pictures in black and white on conventional monochrome receivers.

On October 15, 1953, NTSC color television was demonstrated at the Hotel Waldorf-Astoria, New York City, and thirteen color-television receivers, produced by United States manufacturers, were placed in operation. Color signals were transmitted by New York City networks.

In March, 1953, standards were published by the Institute of Radio Engineers. These terms are now in use in the television industry, and by television engineers in the field.

(162) J. F. Fisher, "Generation of NTSC color signals," Proc. I.R.E., vol. 41; March, 1953.
(163) D. Richman, "Theory of synchronization, applied to NTSC color television." Presented at the 1953 IRE National Convention, New York, N. Y.; March, 1953.
(164) W. E. Good, "Color synchronization in the NTSC color television receiver by means of the crystal filter." Presented at the 1953 IRE National Convention, New York, N. Y.; March, 1953.
(165) P. W. Howells, "Transients in color television." Presented at the 1953 IRE National Convention, New York, N. Y.; March, 1953.
(166) C. E. Page, "A monitoring system for NTSC color television signals." Presented at the 1953 IRE National Convention, New York, N. Y.; March, 1953.
(167) R. D. Kell and A. C. Schroeder, "Optimum utilization of the radio frequency channel for color TV." Presented at the 1953 IRE National Convention, New York, N. Y.; March, 1953.
(168) W. R. G. Baker, "Specifications for field test of NTSC compatible color television," Proc. I.R.E., vol. 41; May, 1953.
(169) F. J. Bingley, "Colorimetry in color television," Proc. I.R.E., vol. 41; July, 1953.
(170) M. I. Burgett, Jr., "A subjective study of color synchronization performance," Proc. I.R.E., vol. 41; August, 1953.
(171) Standards on Television: Definitions of Color Terms, Part I, 1953, Proc. I.R.E., vol. 41; March, 1953.
(172) J. F. Fisher, "Alignment of a monochrome TV transmitter for broadcasting NTSC color signals." Presented at the National Electronics Conference, Chicago, Illinois; September, 1953.
(173) J. B. Chatten and R. C. Moore, "Transition effects in compatible color television." Presented at the National Electronics Conference, Chicago, Illinois; September, 1953.
(174) G. H. Brown and D. G. C. Luck, "Principles and development of color television systems," *RCA Rev.*, vol. 14; June, 1953.
(175) R. D. Kell and A. C. Schroeder, "Optimum utilization of the radio frequency channel for color television," *RCA Rev.*, vol. 14; June, 1953.

UHF Television Transmitters: In 1953, manufacturers began producing new types of transmitters for broadcast channels in the uhf region of the radio frequency spectrum (470–890 mc).

New klystrons and tetrodes were developed for use in the new uhf transmitters. Tetrodes were used in transmitters of low power-output, and klystrons were employed in high-power transmitters.

The new klystrons provided the required uhf transmitter power at high efficiency. Propagation studies made throughout the service areas of uhf broadcasting stations indicated that excellent broadcast service was being provided.

(176) W. P. Bennett and H. F. Kazanowski, "One-kilowatt tetrode for the uhf transmitters," Proc. I.R.E., vol. 41; January, 1953.
(177) D. H. Preist, C. E. Murdock, and J. J. Woerner, "High-power klystrons at uhf," Proc. I.R.E., vol. 41; January, 1953.
(178) W. V. Tyminski and A. E. Hylas, "A wide-band hybrid ring for uhf," Proc. I.R.E., vol. 41; January, 1953.
(179) A. E. Rankin, "High-power uhf klystron application." Presented at the 1953 IRE National Convention, New York, N. Y.; March, 1953.
(180) N. P. Hiestand, "High-power uhf klystron amplifier design." Presented at the 1953 IRE National Convention, New York, N. Y.; March, 1953.
(181) H. M. Crosby, "High-power uhf television broadcasting systems." Presented at the 1953 IRE National Convention, New York, N. Y.; March, 1953.
(182) W. H. Sayer, "A uhf transmitter employing a klystron power amplifier." Presented at the AIEE Summer General Meeting, Atlantic City, N. J.; June, 1953.

Television Receivers: Improvements in television receivers, and also progress in the production of uhf converters, receivers, tuners, and antennas for use in the new 470–890 mc broadcast band were reported. There was much development in experimental and prototype models of color receivers, monitors, and allied equipment. Manufacturers investigated the practicability of circuits and design criteria for use in NTSC color receiver development.

Television receivers were improved with respect to noise figure, definition, circuitry, synchronization, and general operation.

During the first eleven months of 1953, 5,600,423 television receivers were sold through retail outlets in the United States, compared with 5,095,220 receivers sold in the same 1952 period.

(183) R. J. Lindeman and C. E. Dean, "Tuner for complete uhf-tv coverage without moving contacts," Proc. I.R.E., vol. 41; January, 1953.
(184) G. E. Boggs, "Gain stable mixers and amplifiers with current feedback." Presented at the 1953 IRE National Convention, New York, N. Y.; March, 1953.
(185) E. O. Keizer, "An automatic level-setting sync and AGC system." Presented at the 1953 IRE National Convention, New York, N. Y.; March, 1953.
(186) J. P. Van Duyne, "Packaged adjacent channel attenuation." Presented at the 1953 IRE National Convention, New York, N. Y.; March, 1953.
(187) W. M. Quinn, "Methods of matrixing in an NTSC color television receiver." Presented at the 1953 IRE National Convention, New York, N. Y.; March, 1953.
(188) E. H. Boden, "Factors affecting the design of vhf-uhf tuners." Presented at the 1953 IRE National Convention, New York, N. Y.; March, 1953.
(189) W. J. Gruen, "Theory of AFC synchronization." Presented at the 1953 IRE National Convention, New York, N. Y.; March, 1953.
(190) K. E. Farr, "A color television receiver for NTSC system." Presented at the 1953 IRE National Convention, New York, N. Y.; March, 1953.

Television and Cathode-ray Tubes: Developments in the field of television and cathode-ray tubes during 1953 centered on improvements in the types of tubes in general use. A study of the transfer characteristics and Mu factor of picture tubes was accomplished.

Considerable improvement was made in the design of instrument type cathode-ray tubes. Greater resolution, reduced "spot size," and more careful alignment of tube structure was noteworthy.

During the first 11 months of 1953, 9,194,851 cathode-ray tubes were sold in the United States, compared to 5,937,647 tubes of the same type sold during an identical period in 1952.

(191) K. Schlesinger, "Transfer characteristics and Mu factor of picture tubes," Proc. I.R.E., vol. 41; April, 1953.
(192) K. A. Hoagland and H. Grossbohlin, "Improved instrument cathode-ray tube design," National Electronics Conference, Chicago, Illinois; September, 1953.

Piezoelectricity

The greatest activity in this field was in ferroelectrics, and much of it was concerned with the pure solid-state physics of this phenomenon. The year was also marked by more extensive application of piezoelectric elements in uses other than frequency control such as transducers, accelerometers, and so forth. The papers of two symposia on applications which have appeared during the year, indicated that as ceramic elements become more highly developed and standardized there will be a wide field of application.

Beautiful, clear, single crystals of quartz for piezoelectric purposes are now grown synthetically in large numbers in a pilot-plant operation. The bibliography on piezoelectricity for 1952 prepared for the U. S. Army Signal Corps in March lists 488 references. These are divided as follows: General 172, Ferroelectricity 103, Resonators 118, Transducers 45, Ultrasonics 57 (some double listings).

The following books and pamphlets was selected as general reference material and to indicate the scope of development in the field:

(193) L. O. Anderson, "Ferroelectrics of barium titanate type, a bibliography," NAVORD (unclassified) Report 1965, NOTS 535, China Lake, California; April, 1952.
(194) Armed Services Electro Standards Agcy., "Information bulletin on quartz crystal units," 14 pp.+2 appendices; Aug. 1952.
(195) Bell Telephone Laboratories, "Piezoelectric crystal units," No. X-75501, 21 pp.+63 data sheets; June, 1953.
(196) L. Bergmann, "Schwingende Kristalle," B. G. Leubner Verlagsgesellschaft, Leipzig, 51 pp.+51 figs.; 1951.
(197) K. S. Van Dyke and O. M. H. Wall, "Bibliography of Piezoelectricity, 1952," Signal Corps Contract DA36-039-sc-73, supplementary volume No. 2, 10th quarterly report, iv+56 pp.; April 30, 1953.
(198) C. J. F. Bottcher, "Theory of electric polarisation," Elsevier Press, Houston, Texas, 492 pp.; 1952.
(199) Brush Development Company, "Piezotronics," 19 pp.; 1953.
(200) E. T. Jaynes, "Ferroelectricity," Princeton University Press, Princeton, New Jersey, 144 pp.; 1953.
(201) T. A. Perls, "Proceedings of symposium on barium titanate accelerometers," NBS report 2654, xx+228 pp.; August, 1953.
(202) D. A. Venn, "Current status of quartz crystal units and circuitry for frequency control," NRL report No. 4140; April 29, 1953.

General

Progress in quartz synthesis has been reported. Structural defects in quartz, of lesser magnitude than the well known twinning, have been studied. Investigation of the metal plating of quartz resonators is yielding important data on the metals themselves. There has been further development of the mathematical methods of handling crystal properties. The practical use of molecular resonance at 27,000 mc as a frequency standard is approaching a trial. The advent of ferroelectric storage elements for computer and switching systems is important.

(203) J. R. Anderson, "Ferroelectric storage elements for digital computers and switching systems," *Elec. Eng.*, vol. 71, pp. 1195–1203; October, 1952.
(204) W. L. Bond and J. Andrus, "Structural imperfections in quartz crystals," *Amer. Mineralogist*, vol. 37, pp. 622–632; July–August, 1952.
(205) W. H. Charbonnet, "Increased quantity quartz synthesis," Brush Development Co., Seventh quarterly progress report, Signal Corps Contract DA36-039-sc-15371, 44 pp., 10 figs.; March 31, 1953.
(206) D. R. Hale, "The properties of synthetic quartz crystals and their growing technique," *Brush Strokes*, pp. 1–8; December, 1952.
(207) D. R. Hale, "Optimum methods for quartz synthesis" (Brush Development Co.), Signal Corps Contract DA36-039-sc-15381, Seven quarterly progress report, 24 pp.; May 31, 1953.
(208) F. G. Fumi, "Matter tensors in symmetrical systems," *Il Nuovo Cimento*, vol. IX, pp. 739–756; September 1, 1952.
(209) R. J. Rauderbaugh and R. B. Belser, "Aging study of metal plating on quartz crystals" (Georgia Institute of Technology), Signal Corps Contract, DA 36-039-sc-42453, Fifth quarterly report, pp. v+71; August 1, 1953.

(210) L. E. Norton, "Investigation and study of practical utilization of molecular absorption phenomena for frequency control" (Radio Corporation of America), U.S. Army Contract DA 36-039-sc-15525, Fourth quarterly report, 19 pp., 16 figs.; April 30, 1953.

(211) A. C. Walker, "Quartz synthesis at high pressures and temperatures" (Bell Tel. Lab., Inc.), U.S. Army Contract DA 36-039-sc-5572, Ninth quarterly progress report, 16 pp., 9 tables, 4 figs.; March 31, 1953.

(212) E. S. Creeger and K. S. Van Dyke, "Piezoelectric matrices" (Wesleyan University), U.S. Army Contract DA 36-039-sc-42587, First quarterly progress report, xi+138 pp.; April 30, 1953.

Ferroelectricity, Antiferroelectricity and Their Application.

During the year, several new ferroelectric materials have been discovered and investigated, and considerable progress has been made in the understanding of domain structure and the mechanism of domain wall motion. A new ferroelectric, lead metaniobate does not crystalize in the perovskite structure as do many other materials, including barium titanate, but rather in a tetragonal cell containing 40 molecules. The Curie temperature is about 550 degrees C. and no other transitions occur. This material has a dielectric constant of 280 and a thickness electromechanical coupling coefficient of 0.26.

The phase diagram of the $PbZrO_3$-$PbTiO_3$ system was investigated and it was shown that with increasing $PbTiO_3$ content the ferroelectric phase becomes more stable than the antiferroelectric phase. For compositions containing more than 42 per cent of $PbTiO_3$, the ceramic is ferroelectric. A number of ferroelectrics were investigated by the Pennsylvania State College group. Shirane and Pepinsky and Holm have investigated the phase transitions in $Cd_2Nb_2O_7$ and $Pb_2Nb_2O_7$. The former becomes ferroelectric at 170 degrees K. and shows a second transition of 85 degrees K., while the latter shows a dielectric peak at 15.4 degrees K. Other ferroelectrics investigated are $LiNH_4C_4H_4O_6$-H_2O and the system $NaNbO_3$-$KNbO_3$. An antiferroelectric is $PbHfO_3$.

Considerable work has been done on domain structure and domain wall motion in ferroelectrics. Several calculations have been made of domain wall thicknesses and in the case of Rochelle salt and KH_2PO_4 it has been shown (Mitsui and Furuichi; Kanzig and Peter) that the wall can at most be several lattice constants thick. This is in contrast to the Bloch wall in ferromagnetic materials which may be 100 lattice constants thick. For a thin wall there is a considerable energy hump to surmount and it appears that thermal as well as electrostatic energy is required to move the wall of a ferroelectric. The propagation velocity of Rochelle salt domain walls has been measured by Mitsui and Furuichi and they have been shown to proceed in a series of Barkhausen jumps. For high fields (100v/cm) the velocity may be as high as 0.25 cm per second. $Y_z = T_4$ shearing stress can also cause the wall to move. Studies by Merz have shown that a "*c*" domain reverses by the nucleation and growth of oppositely poled 180 degree domains and not by domain wall motion. Merz has also shown that saturation polarization for a single crystal is higher than previously measured, being 25×10^{-6} coul/cm², and that the transition is definitely a first order transition. An aging in the elastic, piezoelectric and dielectric properties of barium titanate ceramics has been shown (Mason) to be due to slow 90 degree wall motions which are due to thermally induced motions directed by residual stresses and occur over energy barriers as high as 19 kilocalories per mole. Accelerated aging is obtained by heating ceramic to 70 degrees C. for several weeks.

The performance of $BaTiO_3$ ceramics has been stabilized with respect to temperature and time (Berlincourt and Kulcsar, Mason) by employing additions of $CaTiO_3$ and $PbTiO_3$. These additions lower the second transition temperature and raise the Curie temperature leaving a wide temperature range for which transitions do not occur. It has been suggested that a superposed electric bias reduces the dielectric loss in a barium titanate ceramic.

(213) H. G. Baerwald and D. A. Berlincourt, "Electromechanical response and dielectric loss of prepolarized barium titanate under maintained electrical bias, Part I," *Jour. Acous. Soc. Amer.*, vol. 25, No. 4, pp. 703–711; July, 1953.

(214) D. A. Berlincourt and F. Kulcsar, "Electromechanical properties of $BaTiO_3$ compositions showing substantial shifts as place transtion points," *Jour. Acous. Soc. Amer.*, vol. 24, pp. 709–713; November, 1952.

(215) G. Goodman, "Ferroelectric properties of lead metaniobate," *Jour. Amer. Ceramic Soc.*, vol. 36, No. 11, p. 368–372; November, 1953.

(216) J. K. Holm, "Low temperature dielectric properties of cadmium and lead niobates," *Phys. Rev.*, vol. 92, No. 2, p. 505; October 15, 1953.

(217) F. Jona and R. Pepinsky, "Study of the transition in $LiNH_4$-$C_4H_4O_6\cdot H_2O$," *Phys. Rev.*, vol. 92, No. 3, p. 845; November 1, 1953.

(218) W. Kanzig and M. Peter, "Critical domain size in ferroelectrics," *Phys. Rev.*, vol. 85, pp. 940–41; March 1, 1952.

(219) W. P. Mason, "Low-frequency temperature coefficient of barium titanate ceramics which are stable with time," *Jour. Acous. Soc. Amer.*, vol. 25, No. 4, p. 833; July, 1953.

(220) W. J. Merz, "Domain properties in $BaTiO_3$," *Phys. Rev.*, vol. 88, p. 421; October, 1952.

(221) W. J. Merz, "Double hysteresis loop of $BaTiO_3$ at the curve point," *Phys. Rev.*, vol. 91, No. 3, pp. 513–518; August 1, 1953.

(222) T. Mitsui and J. Furuichi, "Domain structure of Rochelle salt and KH_2PO_4," *Phys. Rev.*, vol. 90, No. 2, pp. 193–202; April 15, 1953.

(223) E. Sawaguchi, "Ferroelectricity versus antiferroelectricity in the solid solutions $PbZrO_3$ and $PbTiO_3$," *Jour. Phys. Soc. Japan*, vol. 8, No. 5, pp. 615–629; September–October, 1953.

(224) G. Shirane and R. Pepinsky, "Dielectric properties and phase transitions of $Cd_2Nb_2O_7$ and $Pb_2Nb_2O_7$," *Phys. Rev.*, vol. 92, No. 2, p. 504; October 15, 1953.

(225) G. Shirane, R. E. Newnham, and R. Pepinsky, "Phase transition in the $NaNbO_3$ in $KNbO_3$ system," *Phys. Rev.*, vol. 92, No. 3, p. 845; November 1, 1953.

(226) G. Shirane and R. Pepinsky, "Phase transitions in antiferroelectric $PbHfO_3$," *Phys. Rev.*, vol. 91, No. 4, pp. 812; August15, 1953.

Resonators

An extended series of mathematical papers were published on elastic resonator theory. Mindlin and his collaborators are making excellent progress in a very difficult field. Studies of quartz and EDT crystal resonators have continued. A review of measuring processes for the several crystal-resonator parameters represents an activity of the IRE Technical Committee on Piezoelectricity. A wire-supported 100 KC GT-cut crystal was reported to have a frequency drift of less than 1 part in 10^8, or ½ millisecond per day in time.

(227) R. Bechmann, "Piezoelectric resonators and oscillators using quartz and synthetic crystals," *Telefunken Ztg.*, vol. 25, pp. 229–245; November, 1952.

(228) R. Bechmann and G. T. Hollins, "A method of mounting EDT crystal resonators by fusion," Post Office Engineering Department, Research report No. 13646; August, 1952.

(229) R. Bechmann, S. Ayers, and C. E. Richards, "Thickness modes of plates excited piezoelectrically," Post Office Engineering Department, Research report No. 13471; May, 1952.

(230) S. Dairiki, T. E. Lawrence, and R. A. Mapleton," Equivalent network representations for solid and mercury delay lines," *Jour. Acous. Soc. Amer.*, vol. 25, pp. 841–853; September, 1953.

(231) E. A. Gerber, "A review of methods for measuring the constants of piezoelectric vibrators," PROC. I.R.E., vol. 41, pp. 1103–1112; September, 1953.

(232) J. P. Griffin, "High stability 100-kc crystal units for frequency standards," *Bell Lab. Rec.*, vol. 30, pp. 433–438; November, 1952.

Transducers

In the field of transducers a paper on methods of analyzing equivalent circuits and another on the validity of ultrasonic absorption as a measure of the radiated power were published. There is a brief theoretical treatment of the bimorph. Measured directivity patterns for several arrays of ceramic Mott resonating cavities along with some electrical impedance diagrams for the arrays were given. Extensive numerical calculations of the directive patterns of linear-point arrays of from 5 to 13 elements were given with extensions of the Dolph and Riblet methods of pattern synthesis to include compensated arrays. In these arrays a uniform progressive phase shift between elements permits steering the directivity maximum to a desired angle.

A Symposium on barium titanate accelerometers was held at the Bureau of Standards in May. A descriptive paper on new miniature tube ceramic accelerometer and the theory of its application to problems studying the ability of electron tubes to stand up under mechanical shock and vibration was published.

(233) W. G. Cady and C. E. Gittings, "On the measurement of power radiated from an acoustic source," *Jour. Acous. Soc. Amer.*, vol. 25, pp. 892–896; September, 1953.

(234) W. G. Cady, "Graphical aids in interpreting the performance of crystal transducers," *Jour. Acous. Soc. Amer.*, vol. 25, pp. 687–696; July, 1953.

(235) L. Camp, "Broad band directional barium titanate transducers," *Jour. Acous. Soc. Amer.*, vol. 25, pp. 297–301; March, 1953.

(236) A. L. Lane, "Design techniques for a high frequency transducer with a wide-beam searchlight pattern," *Jour. Acous. Soc. Amer.*, vol. 25, pp. 697–702; July, 1953.

(237) A. L. Lane, "Barium titanate admittance-temperature characteristics," *Jour. Acous. Soc. Amer.*, vol. 25, pp. 873–878; September, 1953.

(238) A. C. Prichard and M. Bernstein, "Crystal impedance meters replace test sets," *Electronics*, vol. 26, pp. 176–180; May, 1953.

(239) F. G. R. Rockstuhl, "A method of analysis of fundamental and overtone crystal oscillator circuits," *Proc. IEE*, vol. 99, part 3, pp. 377–388; November, 1952.

(240) A. Scheibe, "Pendeluhren, quarzuhren und atomuhren als zeitstandards. Ein vergleich," *Zeitschrift für angewandte Physik*, vol. 5, pp. 307–317; April 15, 1953.

(241) "An investigation of the characteristics of electromechanical filters" (Tufts College), Signal Corps Contract DA 36-039-sc-5402, 11th quarterly report, pp. 1–20; August 15, 1953.

The following papers are theoretical:

(242) R. D. Mindlin, "Investigations of the mathematical theory of vibration of anisotropic bodies" (Columbia University), Signal Corps Contract DA 36-039-sc-15481, quarterly report No. 3; December 31, 1952.

(243) R. D. Mindlin and H. H. Bleich, "Response of an elastic cylindrical shell to a transverse, step shock wave," reprint of paper presented at annual meeting of Amer. Soc. Mech. Eng. at New York, November 30, December 5, 1952.

(244) R. D. Mindlin and H. Deresiewicz, "Timoshenko's shear coefficient for flexural vibrations of beams" (Columbia University), Navy Contract Nonr-266(09), Technical report No. 10, viii+12 pp., 2 figs.; June, 1953.

(245) H. Deresiewicz, "Effects of an oscillating torsional couple on the contact surfaces of elastic spheres" (Columbia University), Navy Contract Nonr-266-(09), Technical report No. 5, viii+14 pp., 3 figs.; February, 1953.

(246) G. Herrmann, "Forced motions of elastic rods" (Columbia University), Navy Contract Nonr-266-(09), Technical report No. 4, viii+15 pp.; February, 1953.

(247) G. Herrmann, "Forced motions of Timoshenko beams" (Columbia University), Navy Contract Nonr-266(09), Technical report No. 9, viii+14 pp.; June, 1953.

(248) T. R. Kane, "Reflection of flexural waves at the edge of a plate" (Columbia University), Navy Contract Nonr-266(09), Technical report No. 6, viii+22 pp., 8 figs.; February, 1953.

(249) O. Mattiat, "Transducers for producing ultrasonic waves," *Jour. Acous. Soc. Amer.*, vol. 25, pp. 291–296; March, 1953.

(250) F. W. Stubner, "Acceleration effects on electron tubes," *Bell Sys. Tech. Jour.*, vol. 32, pp. 1203–1229; September, 1953.

(251) E. G. Thurston, "Theoretical sensitivity of three types of rectangular bimorph transducers," *Jour. Acous. Soc. Amer.*, vol. 25, pp. 870–872; September, 1953.

(252) R. L. Pritchard, "Optimum directivity patterns for linear point arrays," *Jour. Acous. Soc. Amer.*, vol. 25, pp. 879–891, 1010; September, 1953.

Ultrasonics

The six papers of the May, 1952 University of Illinois Symposium in Ultrasonics in Biology and Medicine were published in 1953. Among the factors explored were: heating by intense radiation as a source of therapeutic and biological effects; selective heating of bone tissue; possibilities of a tool for making lesions arising out of the selective action of ultrasonic energy on nerve endings; and the advantages in focusing ultrasonic energy. One paper describes a biologist's approach to the use of ultrasonics in the study of cancer tissue.

(253) W. J. Fry, "Action of ultrasound on nerve tissue—a review," *Jour. Acous. Soc. Amer.*, vol. 25, pp. 1–5; January, 1953.

(254) W. J. Fry and R. B. Fry, "Temperature changes produced in tissue during ultrasonic irradiation," *Jour. Acous. Soc. Amer.*, vol. 25, pp. 6–11; January, 1953.

(255) J. F. Herrick, "Temperatures produced in tissues by ultrasound: experimental study using various technics," *Jour. Acous. Soc. Amer.*, vol. 25, pp. 12–16; January, 1953.

(256) J. F. Lehmann, "The biophysical mode of action of biologic and therapeutic ultrasonic reactions," *Jour. Acous. Soc. Amer.*, vol. 25, pp. 17–25; January, 1953.

(257) P. D. Wall, D. Tucker, F. J. Fry and W. H. Mosberg, Jr., "The use of high intensity ultrasound in experimental neurology," *Jour. Acous. Soc. Amer.*, vol. 25, pp. 281–285; March, 1953.

(258) J. J. Wild and J. M. Reid, "The effects of biological tissues on 15-mc pulsed ultrasound," *Jour. Acous. Soc. Amer.*, vol. 25, pp. 270–280; March, 1953.

Two ultrasonic interferometers were described. An extension of the techniques for measuring properties of materials by use of ultrasonic waves was accomplished by following exponentially decaying pulses as they are reflected back and forth within a solid sample, and from the frequency of return, determining the elastic constant. The design embodies loose acoustic coupling and thermal insulation of the sample so as to permit low temperature studies.

Through the use of more sharply concentrated regions of ultrasonic energy, well away from wall or air surfaces, and by having the liquid stream through the region, pulsed views, of cavitation in water were taken thus isolating an initiation and a catastrophic phase in the process of cavitation. In the latter, phase resonance of the gas pockets and their nonlinear oscillation set up myriads of shock induced microscopic cavities in the nearby water. Ultrasonic beams in fused quartz were rendered photographable as the result of partial depolarization of plane polarized light where instantaneous birefringence occurs under strain.

(259) J. F. W. Bell, "Fixed path ultrasonic interferometer for absorption measurements on gases," *Jour. Acous. Soc. Amer.*, vol. 25, pp. 96–100; January, 1953.
(260) W. G. Cady, "Physics and electronic theory" (California Institute of Technology), Final report Navy Contract Nonr-220(02) and N6onr-262; January 27, 1953.
(261) C. R. Fay, "Cleaning work with the aid of ultrasonic vibration," *Machinery*, vol. 80, pp. 853–855; May, 1952.
(262) M. Greenspan and M. C. Thompson, Jr., "Eleven megacycle interferometer for low pressure gases," *Jour. Acous. Soc. Amer.*, vol. 25, pp. 92–96; January, 1953.
(263) F. L. McNamara and T. F. Rogers, "Direct viewing of an ultrasonic beam in a transparent solid," *Jour. Acous. Soc. Amer.*, vol. 25, pp. 338–339; March, 1953.
(264) H. J. McSkimin, "Measurement of elastic constants at low temperatures by means of ultrasonic waves," *Jour. Appl. Phys.*, vol. 24, pp. 988–997; August, 1953.
(265) G. W. Willard, "Ultrasonically induced cavitation in water: a step-by-step process," *Jour. Acous. Soc. Amer.*, vol. 25, pp. 669–686; July, 1953.

Electron Tubes

Small High-Vacuum Tubes: An approximate theory, giving a graphical correlation in terms of operating parameters and electrode spacing for triodes operating at uhf was presented.

(266) L. S. Giacoletto and H. Johnson, "Uhf triode designs in terms of operating parameters and electrode spacings," Proc. I.R.E., vol. 41, pp. 51–58; January, 1953.

Three papers describing new types of triodes designed for uhf amplifier and oscillator use up to 900 megacycles.

(267) C. E. Horton, "Development of a uhf grounded-grid amplifier," Proc. I.R.E., vol. 41, pp. 73–79; January, 1953.
(268) S. C. Peek, "A disc-seal triode as a uhf amplifier," *Sylvania Technologist*, vol. 6, pp. 81–85; October, 1953.
(269) K. E. Loofbourrow and C. M. Morris, "Stable oscillator for uhf TV receivers," *Electronics*, vol. 25, pp. 118–121; December, 1952.

Rubber-sheet analogs of the two-dimensional electric fields were devised that correct for the change in fields due to space charge. Soft rubber pads were used to deform the rubber sheet at points corresponding to space-charge fields.

(270) G. A. Alma, G. Diemer, and H. Sroendijk, "A rubber membrane model for tracing electron paths in space-charge fields," *Philips Tech. Rev.*, vol. 14, pp. 336–344; May, 1953.

A paper was published on noise in grid-controlled vacuum tubes at very-high frequencies.

(271) G. Diemer and K. S. Knol, "The noise of electronic valves at very high frequencies, part I, the diode," *Philips Tech. Rev.*, vol. 14, pp. 153–164, 236–244; December, 1952, February, 1953.

A technique was described for making a Ramberg vacuum-tube accelerometer with reasonably linear response and phase shift up to its natural frequency.

(272) S. Levy, E. V. Hobbs, W. D. Kroll, and L. Mordfin, "Damping of elastically supported elements in a vacuum tube," *Jour. Res. Nat. Bur. Stand.*, vol. 50, pp. 71–74; February, 1953.

Electron-tube-design problems arising from environmental conditions of shock and vibration were discussed. Methods of construction and calibration of self-generating electromechanical transducers were considered.

(273) F. W. Stubner, "Acceleration effects on electron tubes," *Bell Sys. Tech. Jour.*, vol. 32, pp. 1203–1229; September, 1953.

Power Tubes: High-power transmitting tubes with thoriated-tungsten cathodes were developed and gave a life performance of over thousands of hours. New and improved materials and processing, particularly zirconium getters, are used. Radio-frequency power outputs of over 100 kilowatts were obtained at 15 kv.

(274) E. G. Dorgelo, "High-power transmitting valves with thoriated tungsten cathodes," *Philips Tech. Rev.*, vol. 14, pp. 226–234; February, 1953.
(275) R. B. Ayer, "High-power industrial vacuum tubes having thoriated-tungsten filaments," *Commun. and Elec.*, No. 2, pp. 121–124; May, 1953.

The problem of space-charge-limited current flow in squirrel-cage filament structures commonly used in high-power tubes was investigated. Experimental determinations were made of the equivalent solid-cathode diameter for cage structures with even numbers of wires up to 16.

(276) A. M. Hardie, "Squirrel cage filament structures," *Wireless Eng.*, vol. 30, pp. 196–204; August, 1953.

A forced-air-cooled transmitting tetrode that will deliver 1,200 w at frequencies up to 900 mc was described. It uses an oxide cathode of the matrix or sponge type and ceramic instead of glass insulators.

(277) W. P. Bennett and H. F. Kazanowski, "One-kilowatt tetrode for uhf transmitters," Proc. I.R.E., vol. 41, pp. 13–19; January, 1953.

Design considerations for very-high-voltage high-power rectifiers were discussed. Specific features included use of high vacuum, rather than gas filling, and special "catenary" filaments to withstand electrostatic forces.

(278) T. H. Rogers, "New rectifier tube for extremely high power and voltage levels," *Elec. Eng.*, vol. 72, pp. 51–57; January, 1953.

Gas Tubes: Studies of the fundamental processes of gaseous electronics included investigations of such diverse phenomena associated with spectra, plasmas, surface effects, break-down processes, microwave discharges, glow discharges, arcs, and sparks. Steady progress was made on the unscrambling of the multitudinous and complex mechanisms that occur in even the simplest discharges.

(279) M. A. Biondi, "Doppler broadening of dissociative recombination lines." Presented at 1953 Conference on Gaseous Elecrronics; October 22–24, 1953.
(280) R. N. Varney, "Drift velocities of ions in oxygen, nitrogen, and carbon monoxide," *Phys. Rev.*, vol. 89, pp. 708–711; February, 1953.
(281) D.H. Looney and S. C. Brown, "Excitation of plasma oscillations." Presented at 1953 Conference on Gaseous Electronics; October 22–24, 1953.

(282) R. M. Howe, "Probe studies of energy distribution and radial potential variation in a low pressure mercury arc," *Jour. Appl. Phys.*, vol. 24, pp. 881–894; July, 1953.
(283) H. D. Hagstrum, "Effect of adsorption of common gases on electron ejection by noble gas ions." Presented at 1952 Conference on Gaseous Electrons; September 4–6, 1952.
(284) G. A. Kachickas and L. H. Fisher, "Formative time lags of uniform field breakdown in argon," vol. 91, pp. 775–779; August, 1953.
(285) L. B. Loeb, "Hitherto unrecognized aspects of breakdown streamers." Presented at Conference on Gaseous Electronics; October 22–24, 1953.
(286) L. Gould and S. C. Brown, "Methods of measuring the properties of ionized gases at high frequencies," IV, *Jour. Appl. Phys.*, vol. 24, p. 1053; August, 1953.
(287) B. J. Udelson and J. E. Creedon, "Microwave measurements of the properties of a dc hydrogen discharge." Presented at 1953 Conference on Gaseous Electronics; October 22–24, 1953.
(288) J. D. Cobine and E. E. Burger, "High pressure arc anode phenomena." Presented at 1953 Conference on Gaseous Electronics; October 22–24, 1953.
(289) H. W. Bandel, "Current growth in the formative time lag of sparks." Presented at 1953 Conference on Gaseous Electronics; October 22–24, 1953.

Investigations concerning the processes fundamental to the operation of thyratrons were made.

(290) A. Pakswer and R. Mayer, "Arc drop and deionization time in inert gas thyratrons," *Jour. Appl. Phys.*, vol. 24, pp. 501–509; May, 1953.
(291) E. Koop, "Ignition, discharge, and deionization processes in gas tubes," *Z. Angew. Phys.*, vol. 4, pp. 386–390; October, 1952.
(292) W. C. Dean, "Gas pressure effects on ionization phenomena in high speed hydrogen thyratrons." Presented at I.R.E. National Convention; March, 1953.

A new cold-cathode gas tube was developed for the continuous control and modulation of microwave signals.

(293) D. H. Pringle and E. J. Whitmore, "Gas discharge tubes for control of microwave attenuation," *Jour. Sci. Instr.*, vol. 30, pp. 320–323; September, 1953.

A hot-cathode gas tube that utilizes a noiseless mode of discharge and consequently does not have the noise and instability commonly associated with such tubes was developed.

(294) E. O. Johnson, W. M. Webster, and J. B. Zieker, "Low noise, hot cathode, gas tubes." Presented at I.R.E. National Convention; March, 1953.

A novel vacuum pump based on the properties of a magnetically collimated gas discharge was developed. It has a base pressure of 10^{-6} mm Hg and a pumping speed of 3,000 to 7,000 liters per second.

(295) J. S. Foster, E. O. Lawrence, and E. J. Lofgren, "High vacuum, high speed ion pump," *Rev. Sci. Inst.*, vol. 24, p. 388; May, 1953.

The use of an ionization gauge as an ion pump in attaining vacuums of the order of 10^{-10} mm Hg was described.

(296) D. Alpert, "New developments in the production and measurement of ultra high vacuum," *Jour. Appl. Phys.*, vol. 24, pp. 860–876; July, 1953.

Further studies were made of voltage-regulator tubes.

(297) H. Bache and F. A. Benson, "Peak noise characteristics of some glow discharge tubes," *Jour. of Sci. Instr.*, vol. 30, pp. 124–126; April, 1953.
(298) W. Kiryluk, "Voltage regulator tubes," *Electronic Eng.*, vol. 25, p. 83; February, 1953.

Thyratron grid-circuit reliability with respect to unwanted signals and noise was studied. Circuit and tube limitations were analyzed and corrective modifications outlined.

(299) J. H. Burnett, "Improving gas-tube grid circuit reliability," *Elec. Eng.*, vol. 72, pp. 341–346; April, 1953.

The high power sensitivity of the thyratron and its ability to handle high currents with high efficiency and long life, made possible the extension of its application to include such things as the precision regulation of high currents and voltages and the conversion of low voltage dc to 420 cycles in portable installations.

(300) R. L. Witze, J. V. Kresser, and J. K. Dillard, "Voltage regulation of 12-phase double-way rectifiers." *Elec. Eng.*, p. 617; July, 1953.
(301) R. L. Witze, J. V. Kresser, and J. K. Dillard, "Reactance influence on six-phase rectifier," *Elec. Eng.*, p. 689; August, 1953.
(302) J. H. Burnett, "Fast response high current thyratron power supplies for inductive loads," pp. 627–630; July, 1953.
(303) C. G. Yates, "Free wheeling thyratrons cut autopilot weight," *Electronics*, vol. 26, pp. 103–105; March, 1953.

Cathode-Ray Tubes: For monochromatic television, one new cathode-ray tube is unique only in the unusual neck design and its short over-all length.

(304) J. L. H. Jonker, "A short length direct-view picture tube," *Philips Tech. Rev.*, vol. 14, pp. 361–367; June, 1953.

Theoretical work on the ion problem and on transfer characteristics in cathode-ray tubes point toward improvement in storage tubes and high voltage oscilloscopes.

(305) C. H. Bachman, G. L. Hall, and P. A. Silberg, "Positive and negative ions in cathode ray tubes," *Jour. Appl. Phys.*, vol. 24, pp. 427–433; April, 1953.
(306) K. Schlesinger, "Transfer characteristics and mu factor of picture tubes," PROC. I.R.E., vol. 41, pp. 528–532; April, 1953.

Discussions on contrast and reflection should be of interest to set and cathode-ray-tube manufacturers.

(307) J. H. Haines, "Contrast in cathode ray tubes," *Tele-Tech*, vol. 12, pp. 100–102, 179–181; June, 1953.
(308) M. E. Anduroky, "Measuring reflection from crt faceplates," *Tele-Tech*, vol. 12, pp. 90–91; October, 1953.

Two cathode-ray tubes having special value in research work were described.

(309) R. C. Hergenrother and H. G. Rudenberg, "Direct-reading oscilloscope for 100-kv pulses," PROC. I.R.E., vol. 41, pp. 896–901; July, 1953.
(310) H. J. Peale and R. W. Rochelle, "New high speed cathode ray tube," *Tele-Tech*, vol. 12, pp. 58–61; July, 1953.

Storage Tubes: Storage tubes are being considered much more seriously for data storage, scan conversion, and radar problems. A storage tube symposium was held under auspices of Panel on Electron Tubes Research and Development Board, in Washington last April.

(311) W. T. Dyall, G. R. Fadner, and M. D. Harsh, "Development of an improved graphecon storage tube," *RCA Rev.*, vol. 13, pp. 546–557; December, 1952.
(312) S. T. Smith and H. E. Brown, "Direct-viewing memory tube," PROC. I.R.E., vol. 41, pp. 1167–1171; September, 1953.
(313) L. S. Allard, "Storage cathode-ray tube," *Wireless World*, vol. 59, No. 2, pp. 95–96.

Color-Television Tubes: Most of the work in this extremely active field concerned the development of practical techniques for manufacturing tubes of either the one-gun screw-switching type or the three-gun aperture-mask type.

(314) R. Dressler, "PDF chromatron—A single or multi-gun tri-color cathode-ray tube," Proc. I.R.E., vol. 41, pp. 851–858; July, 1953.

(315) S. Levy and A. K. Levine, "Preparation of phosphor screens for color television tubes," *Sylv. Tech.*, vol. 6, pp. 60–63; July, 1953.

TRICOLOR TUBES

The year 1953 saw tri-color kinescopes for color television mass-produced for the first time. The above scene is part of a pilot production line set up at Lancaster, Pa. (RCA)

Phototubes and Photoconductive Devices: Multiplier phototubes became available in a wide variety of types for radiation monitoring and scintillation counting. Manufacturers' technical data indicate improvements in cathode sensitivity and collection efficiency. In Europe emphasis was placed on reducing the dark current in multiplier phototubes. Several European papers described photocathodes of Li_3Sb.

(316) N. Schaetti and W. Baumgartner, "Investigations of the dark current of photocells with secondary electron multiplication," *Helv. Phys. Acta*, vol. 25, pp. 605–611; November 1, 1952.

(317) E. Morrileau, H. Dormont, and R. Champeix, "Photomultipliers particularly suitable for counting scintillations," *Compt. Rend. Acad. Sci.* (*Paris*), vol. 236, pp. 474–476; February 2, 1953.

(318) W. W. Schultz and R. A. Dewes, "Photovoltaic radiation detector," *Nucleonics*, vol. 11, pp. 49–51; May, 1953.

(319) B. R. Linden, "Five new photomultipliers for scintillation counting," *Nucleonics*, vol. 11, pp. 30–33; September, 1953.

(320) J. B. Birks, "Scintillation Counters," McGraw-Hill Book Co., Inc. New York: Pergamon Press Ltd., London, pp. 21–38; 1953.

Multiplier phototubes were also evaluated in miscellaneous applications.

(321) H. E. Kallmann, "Remodulation in electron multiplier cascades," Proc. I.R.E., vol. 41, pp. 282–283; February, 1953.

Efforts continued to obtain more efficient detectors of both ultraviolet and infrared radiation. Nickel, platinum, and tungsten were investigated as photoemitters and were found to have a maximum quantum efficiency near 10 per cent between 500 and 1,000 Å. Sodium salicylate, serving as a phosphor to convert ultraviolet radiation into visible radiation has been found to have a constant quantum efficiency from 500 to 3,000 Å. The poor life of the Cs-Ag-O photocathode in the presence of secondary-emitting electrodes prompted one investigator to use a Ce-Sm infrared-sensitive phosphor in conjunction with a special multiplier phototube. A very-low dark current was achieved at the same time.

(322) K. Wanatabe and E. C. Y. Inn, "Intensity measurements in the vacuum ultraviolet," *Jour. Opt. Soc. Amer.*, vol. 43, pp. 32–35; January, 1953.

(323) E. Taft and L. Apker, "Photoemission from cesium and rubidium tellurides," *Jour. Opt. Soc. Amer.*, vol. 43, pp. 81–83; January, 1953.

(324) H. E. Hinterbregger and K. Wanatabe, "Photoelectric cells for the vacuum ultraviolets," *Jour. Opt. Soc. Amer.*, vol. 43, pp. 604–608; July, 1953.

(325) W. Baumgartner and N. Schaetti, "A practical form of infra-red sensitive multiplier," *Helv. Phys. Acta*, vol. 25, pp. 611–615; November 1, 1952.

Two electronic fluoroscopes operating on the image-converter principle became available and provide small but greatly intensified images of x-ray-excited phosphor screens.

(326) F. H. Marshall, "The electronic fluoroscope," *Westinghouse Eng.*, vol. 13, pp. 70–71; March, 1953.

(327) "New device makes x-ray images 1000 times brighter," *Elec. Eng.*, vol. 72, p. 605; July, 1953.

In semiconductors a photosensitivity as high as 10 amperes per lumen was obtained in both cadmium-sulfide cells and the germanium phototransistor. Two manufacturers described the characteristics of their germanium photodiodes and phototransistors.

(328) G. A. Veszi, "A modern single layer selenium photocell," *Jour. Brit. I.R.E.*, vol. 13, pp. 183–189; April, 1953.

(329) J. N. Shive, "The properties of germanium phototransistors," *Jour. Opt. Soc. Amer.*, vol. 43, pp. 239–244; April, 1953.

(330) R. W. Smith and A. Rose, "Current voltage characteristics of cadmium sulfide crystals using ohmic contacts," *Bull. Amer. Phys. Soc.*, vol. 28, p. 21; June 18, 1953.

(331) R. G. Seed and R. B. Holt, "Photodiodes and phototransistors," *Electronic Design*, vol. 1; September, 1953.

Television Camera Tubes: Image iconoscopes were subject to continuing refinements, particularly in Europe. The latest feature consists of a variable image field, providing a 2.5-to-1 change in image size by electron-optical means thereby avoiding changing optical lenses. Cadmium-sulfide photoconductors in the conductron were studied.

(332) H. Bruining, "Quelques points de vue nouveaux concernant la construction et l'utilisation de l'image-iconoscope," *Le Vide*, vol. 7, pp. 1248–1255; November, 1952.

(333) Theile, "The mechanism of signal generation in storage-type television camera tubes," *Jour. Telev. Soc.*, vol. 6, pp. 457–477; October/December, 1952.

(334) R. Barthelemy, "The French origin of the image-orthicon target," *Electronique* (*Paris*), no. 75, pp. 37–41; Feb., 1953.

(335) B. Bartels and M. Munsch, "Etude d'un tube analysateur à couche photoconductrice—le conductron," *Le Vide*, vol. 8, pp. 1320–1325; March, 1953.

(336) J. C. Franken and H. Bruening, "New developments in the image iconoscope," *Philips Tech. Rev.*, vol. 14, pp. 327–335; May, 1953.

(337) H. Smith, "Multicon—A new TV camera tube," *Tele-Tech*, vol. 12, pp. 57, 125; July, 1953.

Magnetrons, Klystrons and Traveling-Wave Tubes

Magnetrons: A new approach to a satisfactory theory of magnetron conduction and oscillation was based on Onsager's thermodynamics of irreversible processes.

(338) P. A. Lindsay and G. D. Sims, "Application of the thermodynamics of irreversible processes to the theory of the magnetron," *Proc. Phys. Soc.*, B, vol. 66, pp. 423–425; May 1, 1953.

Studies were made of amplitude-modulated injection-locked interdigital and inverted magnetrons.

(339) L. L. Koros, "Measurements of some operational characteristics of an amplitude-modulated injection-locked uhf magnetron transmitter," Proc. I.R.E., vol. 41, pp. 4–10; Jan., 1953.
(340) G. Hok, "Calculation of a waveguide-loaded resonator for interdigital magnetrons," Proc. I.R.E., vol. 41, pp. 763–769; June, 1953.
(341) F. Ludi, "Inverted magnetron," Proc. I.R.E., vol. 41, p. 799; June, 1953.
(342) A. Leblond, O. Doehler, and R. Warnecke, "New magnetron oscillator with interdigital circuit," *Compt. Rend. Acad. Sci., Paris*, vol. 236, pp. 55–57; January 5, 1953.
(343) A. Leblond, "Etude d'une ligne interdigitale utilisée comme circuit anodique de magnetron oscillateur pour U.H.F.," *Ann. Radioélec.*, vol. 8, pp. 194–210; July, 1953.

A number of magnetrons for frequency modulation and beacon applications were described.

(344) D. P. Kennedy, "A 50-watt FM magnetron for relay service," *Tele-Tech*, vol. 12, pp. 66–68; August, 1953.
(345) G. A. Espersen and B. Arfin, "A three centimeter magnetron for beacons," *Commun. News*. vol. 13, pp. 61–68; April, 1953.

A study of the noise accompanying the carrier oscillations of cw magnetrons was undertaken to provide a better understanding of the physical mechanisms involved.

(346) D. Middleton, "Noise in cw magnetrons," *Jour. Appl. Phys.*, vol. 24, p. 1065; August, 1953.

The state of the magnetron art was reviewed. A description of one magnetron indicates a cw power output of 1 kw at a wavelength of 12.5 cm and an efficiency greater than 50 per cent.

(347) R. L. Wathen, "Genesis of a generator—the early history of the magnetron," *Jour. Franklin Inst.*, vol. 255, pp. 271–287; April, 1953.
(348) K. Fritz, "The state of magnetron development in Germany," *Funk u. Ton*, vol. 7, pp. 133–138; March, 1953.

Klystrons: A number of papers were concerned with the characteristics of reflex klystrons. Harmonic distortion in a reflex klystron used as a frequency-modulated transmitter was computed. A method for the experimental determination of the mode of oscillation and the bunching-effectiveness factor considered the structure of the repeller space as well as the effect of sapce charge.

(349) E. D. Reed, "Coupled resonator reflex klystron," *Bell Sys. Tech. Jour.*, vol. 32, pp. 715–766; May, 1953.
(350) R. L. Jepsen and T. Moreno, "Fm distortion in reflex klystrons," Proc. I.R.E., vol. 41, pp. 32–36; January, 1953.
(351) M. de Bennetot, "La recherche experimentale de l'ordre d'oscillation et du facteur de rassemblement cinematique d'un klystron reflex," *Ann. Radioélec.*, vol. 8, pp. 103–110; April, 1953.

A uhf high-power klystron for 1,000 mc utilizing three resonator cavities and a bombardment-type tantalum cathode was described.

(352) D. H. Preist, C. E. Murdock, and J. J. Woerner, "High-power klystrons at uhf," Proc. I.R.E., vol. 41, pp. 20–25; January, 1953.

A klystron designed for frequency-modulation applications used the single-cavity two-gap structure with a floating drift space between the two gaps.

(353) M. Chodorow and S. P. Fan, "Floating-drift-tube klystron," Proc. I.R.E., vol. 41, pp. 25–31; January, 1953.

Traveling-Wave Tubes: Developments of traveling-wave and backward-wave tube oscillators yielding power outputs from 0.3 to 200 watts with efficiencies as high as 30 per cent were described.

(354) H. R. Johnson and J. R. Whinnery, "Traveling-wave-tube oscillators," *Trans. I.R.E. PGED-2*, pp. 11–35; January, 1953.
(355) R. Kompfner, "Backward-wave oscillator," *Bell Lab. Rec.*, vol. 31, pp. 281–285; August, 1953.
(356) G. E. Helmke, "Hairpin tube backward-wave oscillator," *Bell Lab. Rec.*, vol. 31, pp. 286–291; August, 1953.
(357) E. C. Dench, "Carcinatron—backward-wave microwave oscillator," *Tele-Tech*, vol. 12, pp. 64–66, 157–165; November, 1953.

A number of traveling-wave tubes were described, power output levels were given and measurements of noise factors were discussed.

(358) W. J. Dodds, R. W. Peter, and S. F. Kaisel, "New developments in traveling-wave tubes," *Electronics*, vol. 26, pp. 130–133; February, 1953.
(359) H. Schnitger and D. Weber, "Measurements on a 10-w helix-type travelling-wave valve for 15-cm wavelength," *Fernmeldetech. Z.*, vol. 6, pp. 66–72; February, 1953.

A number of theoretical papers described large-signal behavior, characteristics in the dispersive region of the delay line, and effect of secondary electrons on noise factor and stability.

(360) A. Nordsieck, "Theory of the large signal behavior of traveling-wave amplifiers," Proc. I.R.E., vol. 41, pp. 630–637; May, 1953.
(361) W. Klein and W. Friz, "Characteristics of the travelling-wave valve in the dispersive region of its delay line," *Arch. elek. (Übertragung)* vol. 7, pp. 236–248; May, 1953.
(362) R. W. Peter and J. A. Ruetz, "Influence of secondary electrons on noise factor and stability of traveling-wave tubes," *RCA Rev.*, vol. 14, pp. 441–452; September, 1953.

Interest was shown in the application of traveling-wave tubes in radio relay systems.

(363) D. C. Rogers, "The travelling-wave tube as output amplifier in centimetre-wave radio links," *Proc. IEE* (*London*), part 3, vol. 100, pp. 151–156; May, 1953.
(364) D. C. Rogers and P. F. C. Burke, "British TV relay uses traveling-wave tubes," *Electronics*, vol. 26, pp. 156–160; June, 1953.

Work continued on spatial-harmonic amplifier tubes.

(365) "Spatial-harmonic t-w tube," *Electronics*, vol. 26, p. 206; March, 1953.
(366) S. Millman, "Spatial-harmonic traveling-wave amplifier," *Bell Lab. Rec.*, vol. 30, pp. 413–416; November, 1952.

Physical Electronics

New Types of Cathodes: A variant of the L cathode, called an impregnated cathode, in which the emitting material, barium aluminate, is dispersed throughout a porous tungsten core was described. This cathode is comparable in performance to the L cathode and may be accurately machined. Since little gas is evolved during processing the required pumping time is less than for the L cathode.

(367) R. Levi, "New dispenser cathode," *Jour. Appl. Phys.*, vol. 24, p. 233; February, 1953.
(368) R. C. Hughes and P. P. Coppola, "Bariated tungsten emitters," *Jour. Appl. Phys.*, vol. 23, pp. 1261–1262; November, 1952.

A sintered cathode of nickel powder and barium oxide, which can be made in planar or cylindrical form, was developed. This cathode is undamaged by exposure to air and is resistant to gas poisoning.

(369) D. MacNair, R. T. Lynch, and N. B. Hannay, "Molded thermionic cathode," *Jour. Appl. Phys.*, vol. 24, pp. 1335–1336; October, 1953.

A comprehensive description was given of dispenser cathodes using porous tungsten and barium oxide or thoria.

(370) H. Katz, "Metal capillary cathodes," *Jour. Appl. Phys.*, vol. 24, pp. 597–603; May, 1953.

Interface Effects: Various methods of measuring the impedance of the interface layer formed in oxide cathodes between the metal core and the oxide layer were presented. The effect of this impedance on the transient response of the tube was investigated.

(371) I. L. Sparks and H. R. Phillip, "Retarding potential method for measuring electrical conductivity of oxide-coated cathodes," *Jour. Appl. Phys.*, vol. 24, pp. 453–461; April, 1953.
(372) A. Van der Ziel, "A simple method of measuring interface impedance," *Jour. Appl. Phys.*, vol. 24, p. 496; April, 1953.
(373) J. R. Tillman, J. Butterworth, and R. E. Warren, "Dependence of mutual conductance on frequency of aged oxide-cathode valves and its influence on their transient response," May, 1953.
(374) A. P. Weber, "Investigation of oxide-coated cathodes with an interface-resistance layer," *Telefunken Zeit.*, vol. 26, pp. 123–127; March, 1953 (German).
(375) H. M. Wagner, "Cathode-interface impedance and its measurement," *Proc. N.E.C. (Chicago)*, vol. 8, pp. 553–561; 1952.

The presence of tungsten, titanium, or aluminum in cathode cores was found to cause the formation of an interface compound that is gradually replaced by Ba_2SiO_4 when silicon is present as a minor impurity. By the choice of suitable impurities in the cathode core, it is possible to retard the growth of a high-resistance interface.

(376) A. Eisenstein, H. John, and J. H. Affleck, "Double activators in oxide cathode base alloys," *Jour. Appl. Phys.*, vol. 24, pp. 631–632; May, 1953.

Studies were made of the noise produced by the interface layer.

(377) H. O. Berktay, "Noise in interface resistance," *Wireless Eng.*, vol. 30, pp. 48–49; February, 1953.
(378) W. W. Lindemann and A. Van der Ziel, "On the flicker noise caused by an interface layer," *Jour. Appl. Phys.*, vol. 23, pp. 1410–1411; December, 1952.

Noise in Oxide Cathodes: It was found that the excess noise caused by the passage of current through an oxide cathode is proportional to the square of the current and the noise increases when the activity of the cathode decreases. The contribution of this excess noise to the flicker effect was also studied.

(379) K. Amakusu, "Excess thermal noise due to current flow through (BaSrO) oxide coating," *Jour. Appl. Phys.*, vol. 23, pp. 1330–1332; December, 1952.

The effect of temperature and impurities on flicker noise in oxide cathodes was investigated.

(380) T. B. Tomlinson, "Temperature dependence of low frequency fluctuations in thermionic emitters," *Jour. Appl. Phys.*, vol. 24, pp. 611–615; May, 1953.
(381) Y. Inuishi and Y. Tsung-Che, "Influence of impurity atoms on flicker noise," *Jour. Phys. Soc. (Japan)*, vol. 8, pp. 565–567; July–August, 1953.

Effect of Contaminants on Cathode Emission: The dependence of oxide-cathode emission on the migrating impurities from tube parts other than the cathode was examined. This investigation demonstrated that the effect of the cathode base metal alone on emission can be assessed only in special diode structures that do not contribute active impurities.

(382) I. E. Levy, "Effect of impurity migrations on thermionic emission from oxide cathodes," Proc. I.R.E., vol. 41, pp. 365–368; March, 1953.

The emission decay caused by contaminations on the anode was measured and the voltage dependence of the effect indicated that the contamination is caused mainly by evaporation of barium-oxide during activation.

(383) K. Amakusu and T. Imai, "Emission decay phenomena due to the contaminated anode," *Jour. Appl. Phys.*, vol. 24, pp. 107–109; January, 1953.

The decay and recovery of emission and conductivity of oxide cathodes exposed to oxygen were studied, using mass-spectrometer techniques. The results were in agreement with the Loosjes-Vink theory of conduction in the oxide cathode.

(384) A. A. Shepherd, "Effects of oxygen on the electrical properties of oxide cathodes," *Brit. Jour. Appl. Phys.*, vol. 4, pp. 70–75; March, 1953.

The positive and negative ions formed in cathode-ray tubes were identified; hydrogen was found to be the most prevalent. It was found that aluminized screens offer little protection from ion burn.

(385) C. H. Bachman, G. L. Hall, and P. A. Silberg, "Positive and negative ions in cathode-ray tubes," *Jour. Appl. Phys.*, vol. 24, pp. 427–433; April, 1953.

Thermionic Emission (general): Graphs were prepared for the rapid and convenient determination of the work function of thermionic emitters.

(386) C. G. J. Jansen and R. Loosjes, "Graphs for the rapid calculation of the work function of thermionic emission," *Philips Res. Rep.*, vol. 8, pp. 81–90; April, 1953.

The construction of a tube for detecting the electron-velocity distribution of emitting surfaces, especially of oxide coatings at high current densities was described. It was possible to measure electron velocities to within an accuracy of 1 per cent.

(387) C. G. J. Jansen and R. Loosjes, "Velocity distribution of electrons of thermionic emitters under pulsed operation," *Philips Res. Rep.*, vol. 8, pp. 21–34; February, 1953.

Space charge in the oxide layer of a cathode was shown to have a pronounced effect on the slope of the current-voltage characteristic in the Schottky region, while in the space-charge-limited region the effect is negligible. Experimental studies confirmed this analysis.

(388) T. Shindo, "Space charge effect in the oxide cathode layer," *Jour. Phys. Soc. (Japan)*, vol. 8, pp. 494–499; July–August, 1953.

The above effect was also considered in a comprehensive experimental study of the oxide cathode. A considerable body of experimental evidence was integrated to explain many of the anomalies of oxide-cathode behavior.

(389) L. S. Nergaard, "Studies of the oxide cathode," *RCA Rev.*, vol. 13, pp. 464–545; December, 1952.

Three review articles concerning thermionic emission and oxide cathodes appeared.

(390) D. A. Wright, "Survey of our present knowledge of thermionic emitters," *Proc. IEE* (*London*), part 3, vol. 100, pp. 125–142; May, 1953.
(391) R. Burion, "Semiconductors and oxide coated cathodes," *Onde Elec.*, vol. 33, pp. 36–39; January, 1953 (French).
(392) A. N. Bounds and P. N. Hambleton, "Nickel-base indirectly heated oxide coated cathode," *Elec. Eng.*, vol. 72, pp. 536–540; June, 1953.

The chemistry of oxide cathodes was reviewed. Factors affecting cathode life were considered.

The treatment was based on the widely supported theory that excess barium is required to activate the coating. Accordingly, a search was made for materials of sufficient reducing power to serve as activators.

(393) E. S. Rittner, "Theoretical study of the chemistry of the oxide cathode," *Philips Res. Rep.*, vol. 8, pp. 184–238; June, 1953.

The properties of thoria cathodes were studied.

(394) G. Mesnard, "Contribution to the study of thoria cathodes," *Jour. Phys. et le Radium*, vol. 14, pp. 179–191; March, 1953 (French).

Field and Secondary Emission: Thin films of magnesium oxide were found to emit very large secondary-emission currents under the influence of an electric field. Under appropriate conditions, these currents may persist for many hours after removal of the primary beam of electrons.

(395) D. Dobischek, H. Jacobs, and J. Freely, "Mechanism of self-sustained electron emission from magnesium oxide," *Phys. Rev.*, vol. 91, pp. 804–812; August 15, 1953.

Field emission from tungsten points of known geometry was correlated with the wave-mechanics field-emission theory.

(396) W. P. Dyke, J. K. Trolan, W. W. Dolan, and G. Barnes, "The field emitter: fabrication, electron microscopy and electric field calculations," *Jour. Appl. Phys.*, vol. 24, pp. 570–576; May, 1953.

Changes with time of the secondary emission from barium-oxide films were observed to be dependent on the film thickness. Electron bombardment reduces the thermionic emission at room temperature but above 500 degrees C. the bombardment is very effective in activating the cathode.

(397) J. Woods and D. A. Wright, "Changes in secondary and thermionic emission from barium oxide during electron bombardment," *Brit. Jour. Appl. Phys.*, vol. 4, pp. 56–61; Feb., 1953.

Photo-Electric Effects: Fatigue in Ag-Cs photoelectric tubes was measured and the conditions necessary for obtaining high accuracy in photoelectric photometry with these phototubes were discussed.

(398) G. Kuwabara, "On the fatigue of Ag-Cs photoelectric tubes," *Jour. Phys. Soc. Japan*, vol. 8, pp. 229–233; March–April, 1953.

The optical properties of lead sulphide, selenide, and telluride were measured in the wavelength interval of 0.5–3μ.

(399) D. G. Avery, "Optical constants of lead sulphide, lead selenide and lead telluride in the 0.5–3 μ region of the spectrum," *Proc. Phys. Soc.*, B, vol. 66, pp. 130–140; February, 1953.

Cesium and rubidium tellurides were studied as photoemitters. These materials are of interest for ultraviolet photometry.

(400) E. Taft and L. Apker, "Photoemission from cesium and rubidium tellurides," *Jour. Opt. Soc. Amer.*, vol. 43, pp. 81–83; February, 1953.

Semiconductors

Semiconductor Devices: In 1953, additional knowledge was obtained from fundamental measurements. Mass production of junction transistors began to become a reality. Progress toward higher-frequency operation continued. Progress in the use of semiconducting intermetallic compounds was made although the published material did not yet fully reflect the undercurrent of interest in these materials. Much engineering effort went into the packaging of transistors to achieve a long life. A trend toward hermetically sealed units was apparent, but it was still too early for much life-test data to be published.

General: A second book was published devoted primarily to the transistor. Although dealing mainly with applications, it also contained sections relating to an understanding of the physical phenomena of the device itself. A comprehensive article on the theory and application of the transistor and covering conduction in semiconductors, energy levels, electron physics, transistor action, equivalent circuits, and small signal operation appeared serially.

(401) R. F. Shea, Editor, "Principles of Transistor Circuits," John Wiley and Sons, Inc., New York, N. Y.; 1953.
(402) A. Coblenz and H. L. Owens, "Transistors: theory and application," "Part 1," *Electronics*, vol. 26, pp. 96–102; March, 1953; "Part 2, Energy levels in transistor electronics," *Electronics*, vol. 26, pp. 138–141; April, 1953; "Part 3, Physical properties of electrons in solids," *Electronics*, vol. 26, pp. 162–165; May, 1953; "Part 4, Transistor action in germanium and silicon," *Electronics*, vol. 26, pp. 166–171; June, 1953; "Part 5, Point contact transistor operation," *Electronics*, vol. 26, pp. 158–163; July, 1953; "Part 6, Operation of junction transistors," *Electronics*, vol. 26, pp. 156–161; August, 1953; "Part 7, Equivalent transistor circuits and equations," *Electronics*, vol. 26, pp. 156–161; September, 1953; "Part 8, Small-signal transistor operation," *Electronics*, vol. 26, pp. 158–163; October, 1953.

Exploration of Principles: Exploratory studies of the operation and of the extension of the performance range were described in a number of papers. In one paper, the Hall effect was proposed as a pure production modulator and to get nonreciprocal transmission. Another paper described a specially constructed device with two ohmic contacts that had a stable negative-resistance characteristic. The addition of a fourth electrode to the junction transistor resulted in a new device, the transverse-field tetrode, with very considerable improvement in high-frequency response. Space-charge-limited current flow in germanium was analyzed for both the low-

and high-field cases and the results for the latter were tested experimentally. The field distribution was analyzed in a reverse-biased *n*-intrinsic-*p* configuration showing progressive penetration of the field with increasing voltage. The point-contact transistor still leads as a high-frequency oscillator.

(403) W. P. Mason, W. H. Hewitt, and R. F. Wick, "Hall effect modulators and 'gyrators' employing magnetic field independent orientations in germanium," *Jour. Appl. Phys.*, vol. 24, pp. 167–175; February, 1953.
(404) I. A. Lesk and V. P. Mathis, "The double-base diode: a new semiconducting device," *Convention Rec. IRE*, part 6, pp. 2–8; 1953.
(405) R. L. Wallace, Jr., L. G. Schimpf, and E. Dickten, "High frequency transistor tetrode," *Electronics*, vol. 26, pp. 112–113; January, 1953.
(406) W. Shockley and R. C. Prim, "Space-charge limited emission," *Phys. Rev.*, vol. 90, pp. 753–758; June 1, 1953.
(407) G. C. Dacey, "Space-charge limited hole current in germanium," *Phys. Rev.*, vol. 90, pp. 759–763; June 1, 1953.
(408) R. C. Prim, "D-C field distribution in a 'swept-intrinsic' semiconductor configuration," *Bell Sys. Tech. Jour.*, vol. 32, pp. 665–694; May, 1953.
(409) G. M. Rose and B. N. Slade, "Transistors operate at 300 mc," *Electronics*, vol. 25, pp. 116–118; November, 1952.

Properties of Devices, Specifications and Measurements: Transistor characteristics were discussed with the help of three independently developed vacuum-tube analogies. The existence and application of two cases of transistor symmetry were pointed out.

(410) L. J. Giacoletto, "Transistor characteristics at low and medium frequencies," *Tele-Tech*, vol. 12, pp. 97–99, 150–153; March, 1953.
(411) H. E. Hollman, "Transistortheorie und Transistorschaltungen," *Arch. elek.* (*Übertragung*), vol. 7, pp. 315–327; July, 1953.
(412) J. M. Moulon, "Proprieties et utilisation des transistrons," *Onde Elec.*, vol. 33, pp. 27–35; January, 1953.
(413) G. C. Sziklai, "Symmetrical properties of transistors and their applications," Proc. I.R.E., vol. 41, pp. 717–724; June, 1953.

Properties important to pulse operation, as applied to switching and computing, were described. Transmission and delay-line techniques were used to evaluate the transient behavior of junction transistors. Several simple switching circuits were analyzed in terms of device characteristics and the properties of diode gates and point-contact switching transistors were described in detail.

(414) N. H. Enenstein and M. E. McMahon, "Pulse response of junction transistors," *Trans. I.R.E. Prof. Group on Electron Devices*, vol. ED-3, pp. 5–8; June, 1953.
(415) W. F.Chow and J. J. Suran, "Transient analysis of junction transistor amplifiers," Proc. I.R.E., vol. 41, pp. 1125–1129; September, 1953.
(416) L. W. Hussey, "Semiconductor diode gates," *Bell Sys. Tech. Jour.*, vol. 32, pp. 1137–1154; September, 1953.
(417) A. E. Anderson, "Transistors in switching circuits," *Bell Sys. Tech. Jour.*, vol. 31, pp. 1207–1249; November, 1952.

The reliability of transistors especially with respect to high-humidity environment was analyzed. Evidence was presented to show that germanium diodes are more reliable if hermetically sealed.

(418) R. M. Ryder and W. R. Sittner, "Transistor reliability studies," *Convention Rec. I.R.E.* part 6, pp. 9–14; 1953.
(419) J. W. Dawson, "Germanium diodes sealed in glass," *Sylvania Technologist*, vol. 6, pp. 1–4; January, 1953.

Complete specification of transistor performance requires the definition of useful parameters and provision for their measurement. Equivalent circuit representations were codified for convenient use and an unambiguous set of symbols was proposed for transistor parameters. Bridges were described that use a multifrequency test signal to measure complex transistor admittance between 1 kc and 1 mc. Direct-reading equipment was designed to measure 1-kc transistor noise figures. A fuse bolometer was employed in evaluating uhf crystal diodes at high frequencies and equipment was also described to measure their audio-frequency admittance.

(420) L. J. Giacoletto, "Terminology and equations for linear action four-terminal networks including transistors," *RCA Rev.*, vol. 14, pp. 28–46; March, 1953.
(421) G. Knight, Jr., R. A. Johnson, and R. B. Holt, "Measurement of the small signal parameters of transistors," Proc. I.R.E., vol. 41, pp. 984–989; August, 1953.
(422) L. J. Giacoletto, "Equipments for measuring junction transistor admittance parameters for a wide range of frequencies," *RCA Rev.*, vol. 14, pp. 269–296; June, 1953.
(423) R. F. Marrithew, "Noise analyzer for transistor production," *Electronics*, vol. 26, pp. 136–137; May, 1953.
(424) N. DeWolf, "Testing uhf-tv mixer crystals," *Electronics*, vol. 26, pp. 156–160; April, 1953.

A number of oscilloscopic characteristic-curve tracers were devised.

(425) J. Kurshan, R. D. Lohman, and G. B. Hersog, "Cathode-ray tube plots transistor curves," *Electronics*, vol. 26, pp. 122–127; February, 1953.
(426) B. J. O'Neill and Arthur Gutterman, "Methods and equipment for transistor testing," *Electronics*, vol. 26, pp. 172–175; July, 1953.
(427) D. R. Fewer, "Transistor characteristics obtained by pulse techniques," *Convention Rec. IRE*, part 9, pp. 53–57; 1953.
(428) H. G. Follingstad, "A transistor alpha sweeper," *Convention Rec. IRE*, part 9, pp. 64–71; 1953.
(429) W. E. Morrow, Jr., "Measurement of transistor parameters by cro and other means," *Convention Rec. IRE*, part 9, pp. 45–52; 1953.

Device Analysis: The relation of electric properties to physical structure was extensively studied. A transmission-line equivalent circuit was suggested to explain the variation of collector impedance with frequency. Delayed carriers in the base region offered an explanation for some features of transient behavior of transistors for both small and large signals. Good agreement was obtained between calculated and measured values of current gain in junction transistors. The general problem of transport of added current carriers in a semiconductor was also treated.

(430) R. L. Pritchard, "Collector-base impedance of a junction transistor," Proc. I.R.E., vol. 41, p. 1060; August, 1953.
(431) H. G. Bassett and J. R. Tillman, "Some transient properties of transistors," *Brit. Jour. Appl. Phys.* (*London*), vol. 4, pp. 116–117; April, 1953.
(432) F. S. Goucher and M. B. Prince, "Interpretation of α-values in *p-n* junction transistors," *Phys. Rev.*, vol. 89, pp. 651–653; Feb. 1, 1953.
(433) W. van Roosbroeck, "Transport of added current carriers in homogeneous semiconductor," *Phys. Rev.*, vol. 91, pp. 282–289; July 15, 1953.

The behavior of diodes and *p-n* junctions was clarified by investigating the location of the space-charge layer. Storage effects at junctions were discussed by several authors in terms of diffusion and lifetime of minority carriers. Conductivity modulation played a role in explaining transit-time effects in junction rectifiers. A phase shift of thermal origin in selenium rectifiers was used to explain an incremental negative capacitance.

Temperature studies of contacts to selenium gave results which were in agreement with the theoretical voltage-current characteristic but further clarification was needed for behavior of effective diffusion potentials.

(434) J. S. Saby and W. C. Dunlap, Jr., "Impurity diffusion and space charge layers in fused impurity *p-n* junction," *Phys. Rev.*, vol. 40, pp. 630–632; May 15, 1953.
(435) G. Shulman and M. E. McMahon, "Recovery currents in germanium *p-n* junction diodes," *Jour. Appl. Phys.*, vol. 24, pp. 1267–1272; October, 1953.
(436) B. R. Gossick, "Post-injection barrier emf of *p-n* junction," *Phys. Rev.*, vol. 91, pp. 1012–1013; August 15, 1953.
(437) R. Bray and B. R. Gossick, "Effect of transit time on Ge rectifier behavior," *Phys. Rev.*, vol. 91, pp. 1011–1012; August 15, 1953.
(438) W. Oldekop, "Zur Kapazität des Selengleichrichters," *Zeit. Fuer Phys.*, vol. 134, pp. 66–77; No. 1, 1952.
(439) E. W. Saker, "Temperature variation of the rectifier characteristics at selenium contacts," *Proc. Phys. Soc.* (*London*), B, vol. 64, pp. 990–991; November, 1952.

Details of point-contact transistor behavior were outlined. Hypotheses on forming of collectors were studied by a "double-point" transistor having two adjacent formed spots. The empirical design of point-contact transistors with regard to contact and semiconductor material, spacing, and forming was discussed. A theory of diode and transistor characteristics was given which takes account of the decrease in carrier mobility for strong electric fields.

(440) R. Thedieck, "Beitrag zur Kenntnis des Mechanismus von Punktkontakt-transistoren," *Z. angew. Phys.*, vol. 5, No. 4, pp. 165–166; 1953.
(441) B. N. Slade, "Factors in the design of point-contact transistors," *RCA Rev.*, vol. 14, pp. 17–27; March, 1953.
(442) H. Krömer, "Zur Theorie des Germaniumgleichrichters und des Transistors," *Zeit. Fuer Phys.*, vol. 134, No. 4, pp. 435–450; 1953.

The reverse characteristics of diodes were studied. One paper explained the effect of germanium heating in causing negative resistance. A new theory took into account the radial symmetry and the presence of positive holes in the inversion region of the semiconductor.

(443) H. L. Armstrong, "Thermal effects in point contact rectifiers," *Jour. Appl. Phys.*, vol. 24, pp. 1332–1333; October, 1953.
(444) J. H. Simpson and H. L. Armstrong, "Reverse characteristics of high voltage point contact germanium rectifiers," *Jour. Appl. Phys.*, vol. 24, pp. 25–34; January, 1953.

Large current gains in filamentary transistors were explainable if nearly intrinsic material is employed. The theory of the field-effect transistor was extended and verified experimentally.

(445) W. van Roosbroeck, "Large current amplifications in filamentary transistors," *Jour. Appl. Phys.*, vol. 23, pp. 1411–1412; December, 1952.
(446) G. C. Dacey and I. M. Ross, "Unipolar field-effect transistor," Proc. I.R.E., vol. 41, pp. 970–979; August, 1953.

Power transistor design was aided by one study of high-temperature behavior and by another that analyzed static characteristics. The temperature dependence of the hook mechanism of current amplification was discussed in relation to the trap theory.

(447) L. D. Armstrong and D. A. Jenny, "Behavior of germanium junction transistors at elevated temperatures and power transistor design," *Convention Rec. IRE*, part 6, pp. 22–26; 1953.
(448) N. P. Salz, "Some general considerations in semiconductor power-rectifier design," *Sylvania Technologist*, vol. 6, pp. 73–75; July, 1953.
(449) "Some remarks on the temperature dependence of alpha in point contact transistors," *Trans. Prof. Group on Electron Devices*, vol. PGED-1, pp. 25–30; November, 1952.

Noise: One study of noise in semiconductors presented a quantitative theory that supported the hypothesis that part of the noise arises from minority carriers that are emitted in random bursts and recombine at the surface. The low-frequency dependence was ascribed to the Brownian movement of surface traps. Several investigations of shot noise produced good agreement between theory and experiment. At higher frequencies, noise in a *p-n-p* junction transistor could be explained as shot noise plus thermal noise.

(450) H. Suhl, "Theory of magnetic effects on the noise in a germanium filament," *Bell Sys. Tech. Jour.*, vol. 32, pp. 647–664; May, 1953.
(451) L. Bess, "Possible mechanism for 1/f noise generation in semiconductor filaments," *Phys. Rev.*, vol. 91, p. 1569; September, 1953.
(452) R. H. Mattson and A. van der Ziel, "Shot noise in germanium filaments," *Jour. Appl. Phys.*, vol. 24, p. 222; February, 1953.
(453) A. van der Ziel, "Shot noise in semiconductors," *Jour. Appl. Phys.*, vol. 24, pp. 222–223; February, 1953.
(454) A. van der Ziel, "A simpler explanation for the observed shot effect in germanium filaments," *Jour. Appl. Phys.*, vol. 24, p. 1063; August, 1953.
(455) "On the shot effect of *p-n* junctions," *Trans. Prof. Group on Electron Devices*, vol. PGED-1, pp. 20–24; November, 1952.
(456) H. C. Montgomery and M. A. Clark, "Shot noise in junction transistors," *Jour. Appl. Phys.*, vol. 24, pp. 1337–1338; October, 1953.
(457) A. van der Ziel, "Note on the shot effect in semiconductors and flicker effect in cathodes," *Physica* (*Amsterdam*), vol. 19, pp. 742–744; August, 1953.

Fabrication Techniques: The techniques used in transistor manufacture were discussed in detail. The forming of transistors was shown to involve the formation of a *p-n* junction. Thermal emf served as a tool in identifying the products of the collector-forming process. The electrical forming of silicon transistors was accomplished through an intermediate metallic insert.

(458) J. D. Fahnestock, "Production techniques in transistor manufacture," *Electronics*, vol. 26, pp. 130–134; October, 1953.
(459) R. Thedieck, "Über die Formierung von Germanium-oberflächen," *Z. angew. Phys.*, vol. 5, No. 5, pp. 163–165; 1953.
(460) M. Kikuchi and T. Onishi, "Thermoelectric study of the electrical forming of germanium rectifiers," *Jour. Appl. Phys.*, vol. 24, pp. 162–166; February, 1953.
(461) H. Jacobs, F. A. Brand, and W. Matthai, "Forming silicon point contact transistors," *Jour. Appl. Phys.*, vol. 24, p. 1340; October, 1953.

In studies basic to alloy-junction fabrication, radioactive-tracer techniques yielded the distribution coefficient of indium and germanium. The formation of *p-n* junctions by lithium diffusion was discussed.

(462) J. J. Dowd and R. L. Rouse, "Distribution coefficient of indium in germanium of crystallization," *Proc. Phys. Soc.* (*London*), B, vol. 66, pp. 60–61; January, 1953.
(463) C. S. Fuller and J. A. Ditzenberger, "Diffusion of Li into Ge and Si," *Phys. Rev.*, vol. 91, p. 193; July 1, 1953.

Some new techniques included the formation of point contacts by evaporation of *p-n* junctions by pressure welding.

(464) E. G. Roka, C. H. Jackson, and R. P. Ulrich, "Evaporated point contact rectifiers," *Jour. Appl. Phys.*, vol. 24, pp. 228–229; February, 1953.
(465) R. G. Shulman and D. M. Van Winkle, "Pressure-welded *p-n* junctions in germanium," *Jour. Appl. Phys.*, vol. 24, p. 224; February, 1953.

Properties of Materials: The properties of germanium were extensively studied with special reference to surface effects. The relation between contact potential and both gaseous ambients and surface recombination was investigated and explained in a theory involving surface traps. Surface channels of *n*-type conductivity on *p*-type germanium were explained. The temperature variation of resistivity over the range −100 degrees C. to +140 degrees C. was calculated and plotted for *n*- and *p*-type germanium. Recombination rate was studied by pulse methods. Experimental results were given on drift mobility versus temperature in germanium. The relation between pulse and carrier mobility was confirmed experimentally. The dependence of mobility on electric-field intensity was determined for both germanium and silicon.

(466) W. H. Brattain and J. Bardeen, "Surface properties of germanium," *Bell Sys. Tech. Jour.*, vol. 32, pp. 1–41; January, 1953.
(467) W. L. Brown, "N-type conductivity on *p*-type Ge," *Phys. Rev.*, vol. 91, pp. 518–527; August, 1953.
(468) P. G. Herkart and J. Kurshan, "Theoretical resistivity and Hall coefficient of impure germanium near room temperature," *RCA Rev.*, vol. 14, pp. 427–440; September, 1953.
(469) E. M. Pell, "Recombination rate in germanium by observation of pulsed reverse characteristic," *Phys. Rev.*, vol. 90, pp. 278–279; April, 1953.
(470) R. Lawrence, "Temperature dependence of drift mobility in Ge," *Phys. Rev.*, vol. 89, p. 1295; March, 1953.
(471) M. B. Prince, "Experimental confirmation of relation between pulse drift mobility and charge carrier drift mobility in Ge," *Phys. Rev.*, vol. 91, pp. 271–272; July, 1953.
(472) E. J. Ryder, "Mobility of holes and electrons in high electric fields," *Phys. Rev.*, vol. 90, pp. 766–769; June, 1953.

Transistor action was obtained with *p*-type specimens of PbS. Measurement of carrier injection in lead sulphide gave a lifetime of half a microsecond for electrons. Transistor action and current gain greater than unity were observed in single crystals of PbTe.

(473) C. A. Hogarth, "Transistor action and related phenomena in lead sulphide specimens from various sources," *Proc. Phys. Soc.* (*London*), B, vol. 66, pp. 216–220; March, 1953.
(474) P. C. Banbury, "Carrier injection and extraction in lead sulphide," *Proc. Phys. Soc.* (*London*), B, vol. 66, pp. 50–53; January, 1953.
(475) C. A. Hogarth, "Transistor action in lead telluride," *Proc. Phys. Soc.* (*London*), B, vol. 65, pp. 958–963; December, 1952.
(476) E. H. Putley, "Intrinsic conduction in PbS, PbSe and PbTe, *Proc. Phys. Soc.* (*London*), B, vol. 65, p. 993; December, 1952.

Properties of some new semiconductor materials were discussed. A pulse heating method enabled resistance-temperature characteristics to be taken from liquid hydrogen temperatures to 650 degrees K. in less than a second.

(477) H. Welker, "Über neue Halbleitende Verbingungen," *Z. Naturf.*, vol. 8a, pp. 248–251; April, 1953.
(478) H. Weiss, "Über die Elektrischen Eigneschaften von InSb," *Z. Naturf.*, vol. 8a, pp. 463–469; August, 1953.
(479) M. Tanenbaum and J. P. Maita, "Hall effect and conductivity on InSb single crystals," *Phys. Rev.*, vol. 91, pp. 1009–1010; August, 1953.
(480) R. B. McQuistan, "Determining properties of bulk semiconductors," *Electronics*, vol. 26, pp. 150–155; June, 1953.

Studies were also made of contact characteristics. The high resistance between two pieces of *p*-type germanium was explained. In another study, field emission was assumed to explain some anomalies in the dc characteristics of a point contact of Mg_2Tio_4.

(481) J. B. Gunn, "Resistance of germanium contacts," *Proc. Phys. Soc.* (*London*), B, vol. 65, pp. 908–909; November, 1952.
(482) A. D. Stuckes, "Electro-thermal behavior of point contacts to semiconductors," *Proc. Phys. Soc.* (*London*), B, vol. 66, pp. 570–587; July, 1953.

Current multiplication in junctions below the Zener voltage was explained in terms of ionization breakdown. Electroluminescence theory was used to explain weak-field photo-current multiplication in ZnS as an avalanche process involving the ionization of donor atoms.

(483) K. G. McKay and K. B. McAfee, "Electron multiplication in Si and Ge," *Phys. Rev.*, vol. 91, pp. 1079–1084; September, 1953.
(484) D. Curie, "Sur l'interpretation d'experiences de photoconductibilite en champs eleves," *Compt. Rend.* (*Paris*), vol. 37, pp. 791–794; October, 1953.

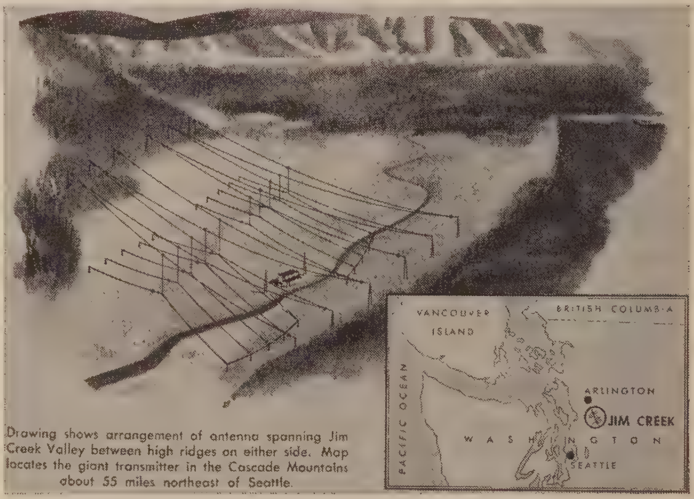
Antennas and Waveguides

Antennas

Over 100 high-gain helical or slot stacked arrays were erected for uhf television broadcasting (470–890 mc).

Some interesting antenna constructions were used in radio astronomy, and are described in the radio astronomy portion of the wave propagation section of this report. An article and book contain extensive bibliographies, discussions and a summary of results obtained.

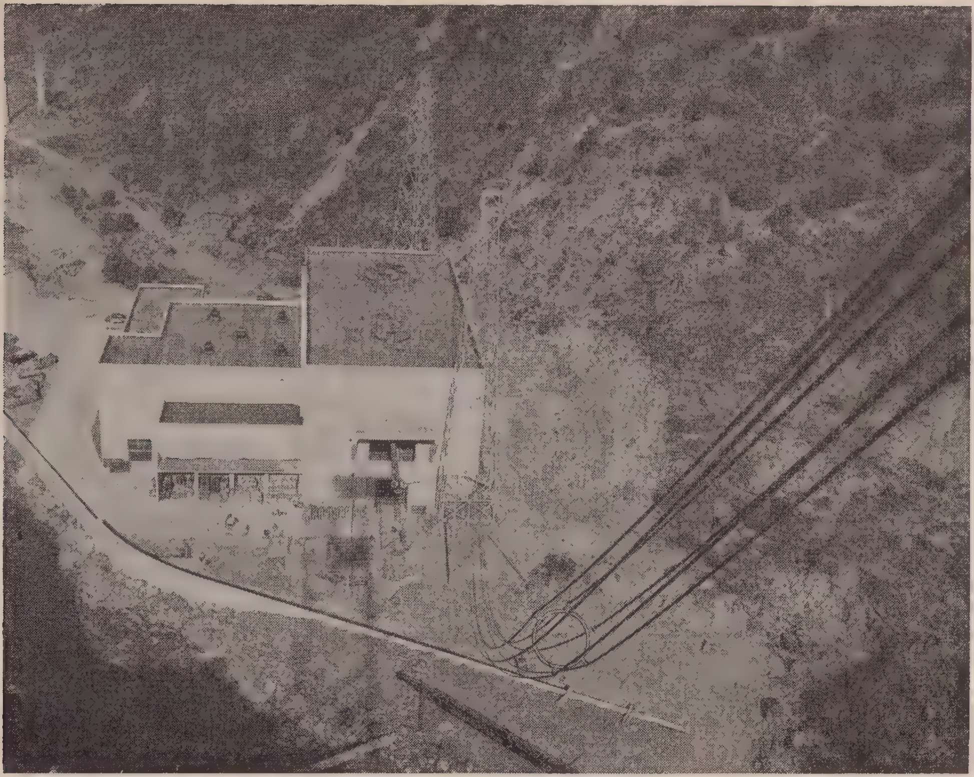
(485) H. H. Klinger, "Radio astronomy," *Jour. Franklin Inst.*, vol. 256, pp. 353–366; October, 1953.
(486) B. Lovell and J. A. Clegg, "Radio Astronomy," Chapman and Hall, London, England; 1952.



Drawing shows arrangement of antenna spanning Jim Creek Valley between high ridges on either side. Map locates the giant transmitter in the Cascade Mountains about 55 miles northeast of Seattle.

The construction of the world's most powerful radio telegraph transmitter (the million watt Jim Creek Project in the Pacific northwest) presented a unique antenna problem. The antenna consists of a capacitance-loaded vertical element 1,000 feet high. The flat top loading elements are supported by 200-foot steel towers erected on opposing mountain ridges. At 15 kilocycles, measurements indicate a total resistance of 0.338 ohm and a radiation resistance of 0.190 ohm resulting in an efficiency of 56.3 per cent.

(487) J. C. Walter, "A million-watt naval communication transmitter," *Communications and Electronics*, pp. 369–374; September, 1953.



Part of the antenna system of the 1,200,000-watt low-frequency transmitting station built for the Navy by RCA at Jim Creek Valley. The antenna—the largest in the world—is suspended across the valley. (Official United States Navy photograph.)

An end-fire antenna based on the surface wave principal was described. It consists of variably spaced and variable diameter metal discs on a rod and represents a generalization of the Yagi type antenna. Beamwidths of 27, 10 and 7 degrees are reported for antenna lengths of 4, 20 and 80 wavelengths respectively. Side lobes of 13 db were reported.

(488) J. C. Simon and G. Weill, "Un nouveau type d'aerien a rayonnement longitudinal," *Ann. Radioélec.*, vol. 33, p. 183; 1953.

Corrugated surface antennas are described rather completely by:

(489) M. J. Ehrlich and L. L. Newkirk, "Corrugated surface antennas," 1953 Convention Record of the IRE, Part 2, Antennas & Communication, pp. 18–33.

Work continued in the field of artificial dialectrics for use in microwave lenses. Refractive indexes as high as 7.2 at 9,364 mc were obtained by imbedding microscopic conducting flakes in paraffin. When highly conductive materials are used the most of the loss is attributed to complex permeability.

(490) J. M. Kelly, J. O. Stenoien, and D. E. Isbell, "Waveguide measurements in the microwave region on metal powders suspended in paraffin wax," *Jour. Appl. Phys.*, vol. 24, pp. 258–262; March, 1953.

Previous work on dielectric antennas and on microwave lenses was summarized.

(491) D. G. Kiely, "Dielectric Aerials," John Wiley and Sons, Inc., New York, N. Y.

(492) J. Brown, "Microwave Lenses," John Wiley and Sons, Inc. New York, N. Y.

Work continued on the diffraction from holes and disks.

(493) W. Andrejewski, "Beugung electromagnetischer Wellere an der leiteuden Kreisscheibe und an der kreisformingen Offnung im leiteuden Schirm," *Z. Angew. Phys.*, vol. 5, p. 178; 1953.

The radiation patterns and curves of radiation conductance for axial and transverse slots in elliptical cylinders were described. It was shown that the degree of surface curvature has a considerable effect on slot conductance.

(494) J. Y. Wong, "Radiation conductance of axial and transverse slots in cylinders of elliptic cross-section," Proc. I.R.E., vol. 41, pp. 1172–1177; September, 1953.

The long, leaky slot or traveling-wave slot antenna is similar to the traveling-wave wire antenna but is more versatile since phase velocity and rate of radiation can be controlled. It is applicable in the microwave region. The complex propagation constant and the radiation patterns were given for various configurations.

(495) J. N. Hines, V. H. Rumsey, and C. H. Walters, "Traveling-wave slot antennas," Proc. I.R.E., vol. 41, pp. 1624–1631; November, 1953.

Effect of manufacturing errors and random deviations from assumed theoretical aperture distributions, such as surface distortions of a parabolic mirror, were considered. Such errors cause corresponding statistical deviation from normal predicted radiation pattern.

(496) L. L. Bailin and M. J. Ehrlich, "Factors affecting the performance of linear arrays," Proc. I.R.E., vol. 41, pp. 235–241; February, 1953.

(497) J. Ruze, "The effect of aperture errors on the antenna radiation pattern," *Supplemento del Nuovo Cimento* (Italian Jour. of Phys.), vol. 9, pp. 364–380; 1953.

Symposia on microwave optics considered the scattering and diffraction of electromagnetic waves, microwave optical systems and their aberrations, and solutions to certain boundary value problems. A number of papers were presented at the International Congress of Optics and Microwaves in Milan, Italy in June 1952. A symposium on microwave optics was held at McGill University, Montreal, Que., Canada, in June, 1953.

Transmission Lines, Waveguides and Microwave Circuits

Several improvements were made in rf components and rf printed circuits used for vhf-uhf television diplexers and tuners. Examples were given of low cost transmission components.

(498) D. D. Grieg and H. F. Engelman, "Microstrip—A new transmission technique for the kilomegacycle range," Proc. I.R.E., vol. 40, pp. 1644–1650; December, 1952.
(499) H. F. Engelman, "Microstrip—a new microwave transmission technique," Trans. of the IRE, PGMTT, No. 1; March, 1953.

Recent work on ferrite indicated that permeability is a tensor quantity which makes them suitable as nonreciprocal transmission elements in the microwave range. Early applications made use of the Faraday rotation exhibited in round waveguide when microwaves are propagated through the ferrite magnetized in the direction of propagation. Work this year resulted in a number of new nonreciprocal transmission components making use of ferrites in rectangular waveguides with transverse magnetization. Reciprocal magnetic properties also proved useful, and a variable microwave attenuator and a microwave magnetometer of extreme sensitivity were described.

(500) P. E. Alley, Jr., "A review of new magnetic phenomena," *Bell Sys. Tech. Jour.*, vol. 32, pp. 1155–1172; 1953.
(501) A. G. Fox, "Performance of ferrites in the microwave range," Trans. of the IRE, PGMTT, No. 2; November, 1953.
(502) N. G. Sakiotis and H. N. Chait, "Properties of ferrites in waveguides," Trans. of the IRE, PGMTT, No. 2; Nov., 1953.

To obtain low-loss transmission of microwave energy the use of the circular electric mode in a round waveguide capable of multimode transmission was examined. For loss determination a reflection pulse technique was used. Mode conversion, mode filtering, and the bend problem were discussed.

(503) S. E. Miller and A. C. Beck, "Low-loss waveguide transmission," Proc. I.R.E., vol. 41, pp. 348–358; March, 1953.

Work continued in the generation of millimeter waves and in the development of suitable components for their transmission. A backward-wave oscillator capable of generating frequencies up to 63 kmc and electronically tunable over a a range of 20 kmc was announced.

(504) R. Kompfner and N. T. Williams, "Backward-wave tubes," Proc. I.R.E., vol. 41, pp. 1602–1611; November, 1953.

A new approach for wide-band impedance transformations in coaxial transmission lines was described. A more general paper dealing with this problem became available.

(505) H. J. Scott, "The hyperbolic transmission line as a matching section," Proc. I.R.E., vol. 41, pp. 1654–1657; November, 1953.
(506) F. Bolinder, "Fourier transforms in the theory of inhomogeneous transmission lines," *Trans. Royal Inst. Tech.*, Stockholm, Sweden, nr. 48; 1951.

Work on a hyperbolic protractor and a new chart for the solution of transmission line and polarization problems was reported.

(507) G. A. Deschamps, "Determination of the reflection coefficients and insertion loss of a waveguide junction," *Jour. Appl. Phys.*, vol. 24, pp. 1046–1050; August, 1953.

Sound Recording and Reproducing

Disc Reproduction

There was a substantial interest in microgroove pickups having lower lateral mechanical impedance. A new technique for the measurement of complex lateral mechanical impedance of pickups was described, capable of measurement up to 10 kc, and tests were made on acoustical and electrical pickups made between 1901 and 1951.

(508) J. G. Woodward and J. B. Halter, "The measurement of the lateral mechanical impedance of phonograph pickups," *Jour. Acous. Soc. Amer.*, vol. 25, pp. 302–305; March, 1953.
(509) J. G. Woodward and J. B. Halter, "The lateral impedance of phonograph pickups," *Audio Eng.*, vol. 37, pp. 23–24, 42–43; July, 1953.

A need to increase the resonant frequency of the stylus mass and groove-compliance was indicated, and data given on the calculated and measured performance of such a pickup designed by use of appropriate scaling factors.

(510) T. Lindenberg, "Analyzing the long playing pickup problem," *Jour. Audio Eng. Soc.*, vol. 1, pp. 140–142; January, 1953.

A theoretical and experimental comparison was made of various methods of measuring distortion in phonograph reproduction, and it was concluded that the CCIF difference-frequency and the harmonic methods are on the whole likely to have excessively limited usefulness due respectively to lack of sensitivity to tracing distortion, and limited frequency range. The SMPTE intermodulation method, using 400 and 4000 cps, has continued to prove satisfactory.

(511) H. E. Roys, "Distortion in phonograph reproduction," *Jour. Audio Eng. Soc.*, vol. 1, pp. 78–85; January, 1953.

New piezo electric pickup cartridges have been developed, using barium titanate, and having considerably improved frequency range.

Disc Recording

Progress was confined to increasing use of already proven techniques and devices, some of them twenty or thirty years old, but just now of commercial value. Use of variable pitch recording showed a wide increase. There was a significant increase in the use of better cutting heads, having good response up to at least 13 to 15 kc, and using electronic or mechanical feedback for distortion reduction. Processing of records was done with greater care, reducing distortion and noise. There was a strong increase in use of heated stylus or heated disc techniques for reduction of noise level of microgroove lacquer discs.

Last year's trend toward a standard recording characteristic with lower crossover frequency and reduced preemphasis has shifted to very general agreement on a characteristic which is part way between the old NARTB and AES characteristics. The new curve has a 500 cps crossover, a high frequency preemphasis conforming to the admittance of a circuit with 75 microsecond time constant, and 3180 microsecond low frequency preemphasis. This curve has been adopted by NARTB, AES, RIA and manufacturers of all types and speeds of discs supplied to the American market.

(512) R. C. Moyer, "Evolution of a recording curve," *Audio Eng.*, vol. 37, pp. 19, 22, 53, 54; July, 1953.

Magnetic Tape Recording

In magnetic tape equipment for home use there was a strong increase in the number of high fidelity models, typically having a frequency range of 12 kc at a tape speed of 7½ inches/sec. Improved designs and techniques for production of heads with 1/4 mil gaps have made this practical.

(513) O. Kornei, "Structure and performance of magnetic transducer heads," *Jour. Audio Eng. Soc.*, vol. 1, pp. 225–231; July, 1953.

There was increased use of 8 to 24 hour recorders. These were either 14 inch reel, low speed recorders using 1/4 inch tape, or rotating head, multitrack recorders, using 3 inch tape.

Improved frequency range has compelled improvement in tape motion, and wow as low as 0.4 per cent (peak to peak) has been measured in newer home equipment.

Portable battery operated 1/4 inch magnetic tape recorders with devices so that the tape could be reproduced synchronously with motion picture film exposed while the sound on tape was recorded, found increasing use.

Radio station interest in wider frequency range at reduced tape speed has led to increased production of recorders with 15 kc range at 7½ inches/sec.

Interest in extremely high signal-to-noise ratios for phonograph-record tape-originals has led to a new FM tape recording system having a signal to noise ratio of 71 db.

(514) W. T. Selsted, "A low-noise fm recording system," *Jour. Audio Eng. Soc.*, vol. 1, pp. 213–215; April, 1953.

The theoretical basis of the magnetic recording process has been given intensive study. A comparison has been made of methods of measuring recorded signal on tape; apparently the difference between the long-gap and short-gap methods, experimentally, does not wholly check theoretical calculations.

(515) W. K. Westmijze, "Studies on magnetic recording," *Philips Res. Rep.*, vol. 8, pp. 148–157, 161–183, 245–269, 343–366; April, June, August, October, 1953.
(516) J. D. Bick, "Methods of measuring surface induction of magnetic tape," *Jour. Audio Eng. Soc.*, vol. 1, pp. 4–9; January, 1953.

A new tape was introduced, reputedly producing higher output and higher signal to noise ratio. There appears to be controversy about its merit. It is believed that additional work is necessary before the quality becomes adequate for general professional use.

(517) L. B. Lueck and W. W. Wetzel, "Performance of high-output magnetic tape," *Electronics*, vol. 26, pp. 131–134; March, 1953.
(517a) C. J. LeBel, "High output tape," *Audio Record*, vol. 9, pp. 6–7; May/June, 1953.

A new reproducing head was developed, using a special miniature cathode-ray tube. Output is linearly proportional to tape magnetization, but gap effect is more serious than with conventional heads.

(518) A. M. Skellett, L. E. Leveridge, and J. W. Gratian, "Electron beam head for magnetic tape playback," *Electronics*, vol. 26, pp. 168–171; Oct., 1953.

Commercial tape duplicating systems have become available, operating at up to 60 inches/sec.

Video tape recorders were demonstrated. One used 12 tracks on tape running at 8⅓ feet/sec, and about 700 tubes, in a multichannel system. The other method used 2 track tape at 30 feet/sec, and a few dozen tubes. By adding three extra tracks the system could handle color as well as black and white. It is interesting to note that standard commercial sound recording tape has been found adequate for so rigorous an application.

Magnetic Film

Magnetic film has become practically universal for original sound recording in film production, and about half the sound track used magnetic film through the editing process.

Current interest in wide screen and 3-D pictures had led to several new methods of causing the sound to move with the picture action by varying the volume of 3 or more speakers. Magnetic methods involve the use of a separate 3 track magnetic reproducer synchronized to the projector or the use of four narrow magnetic tracks striped on the picture film with reduced sprocket width and reproduced through a "penthouse" soundhead mounted on each projector.

(519) "A series of seven articles on magnetic film and striping problems," *Jour. Soc. Mot. Pict. & Telev. Eng.*, pp. 453–507; April, 1953.

One optical method of obtaining some of the effect of moving sound uses darkened intersprocket spaces as control tracks and through a binary signal system gives by switching four loudspeaker combinations. This system, like the four track magnetic stripe system, requires a separate sound head mounted on each projector between the projector and top magazine.

(520) Thomas L. Burnside, "Film industry eyes new stereo sound," *International Projectionist*, vol. 28, pp. 7–8; October, 1953.

Another optical method uses the amplitude of three or more subaudible control frequencies to continuously vary the gain of individual amplifiers feeding each speaker.

This system involves the connection of one control integrator between the output of the existing standard optical sound heads and the power amplifiers. Standard full width optical sound track is used and the system will automatically operate with standard film or film with the 3 or more subaudible control tracks. These control tracks give an added signal to noise ratio over that obtainable without the control integrator.

Information Theory and Modulation Systems

Attention was chiefly focussed on the organization and consolidation of existing data and theories.

(521) F. L. Stumpers, "A Bibliography of Information Theory," Research Laboratory of Electronics, Massachusetts Institute of Technology, Cambridge, Mass.; 1953. Reprinted in *Trans. I.R.E.*, PGIT-2, November, 1953.

Further studies were made of relations between information theory and thermodynamic concept of entropy.

(522) L. Brillouin, "The negentropy principle of information," *Jour. Appl. Phys.*, vol. 24, pp. 1152–1163; September, 1953.

Additional work on the logic of machines was done both here and in England.

(523) M. V. Wilkes, "Can machines think?" PROC. I.R.E., vol. 41, pp. 1230–1234; October, 1953.
(524) C. E. Shannon, "Computers and automata," PROC. I.R.E., vol. 41, pp. 1234–1241; October, 1953.
(525) B. Mandelbrot, "Games of Communication." Presented at Symposium on Statistical Methods in Communication Engineering, University of California; August, 1953.

An important problem is the detection and extraction of signals in the presence of noise. By proper formulation of the detection problem as a test of statistical hypotheses the precise structure of the optimum detector can be specified and minimum detectable signals uniquely determined. The optimum detector is shown to be a computer involving nonlinear operations and terminating in a decision operation that depends on the type of statistical test to be applied by the observer.

This approach to detection recognized the effectiveness of Wald's statistical criteria (in particular the likelihood ratio and the sequential observer) and Fisher's concepts of "sufficient" and "efficient" statistics.

Recent work also emphasized the practical problem of finite-time optimum detection.

(526) D. Middleton, "Statistical Theory of Signal Detection." Presented at Symposium on Statistical Methods in Communication Engineering, University of California; August, 1953.
(527) W. W. Peterson and T. G. Birdsall, "The Theory of Signal Detectability, Parts I and II," Tech. Rep. No. 13; Engineering Research Institute, University of Michigan; June, 1953.
(528) D. Middleton, "Statistical criteria for the detection of pulsed carriers in noise, parts I and II," *Jour. Appl. Phys.*, vol. 24, pp. 371–378, 379–391; April, 1953.
(529) G. W. Preston, "The equivalence of optimum transducers and sufficient and most efficient statistics," *Jour. Appl. Phys.*, vol. 24, pp. 841–844; July, 1953.
(530) D. Slepian, "Estimation of Signal Parameters in the Presence of Noise." Presented at Symposium on Statistical Methods in Communication Engineering, University of California; August, 1953.
(531) E. Reich and P. Swerling, "The detection of a sine wave in gaussian noise," *Jour. Appl. Phys.*, vol. 24, pp. 289–296; March, 1953.

As part of the general detection problem emphasis was directed to the theory of nonlinear filters. A general scheme for classifying nonlinear filters was published.

(532) L. A. Zadeh, "Optimum non-linear filters," *Jour. Appl. Phys.*, vol. 24, pp. 396–404; April, 1953.
(533) O. J. M. Smith, "Statistically almost optimum non-linear network design." Presented at Symposium of Statistical Methods in Communication Engineering, U. of Calif.; Aug., 1953.
(534) A. W. Sullivan and J. M. Barney, "A non-linear statistical filter," *Proc. N.E.C.* (Chicago), vol. 7, pp. 85–91; 1952.
(535) R. E. Scott, S. Fine, and A. MacMullen, "Non-linear filtering and waveshape multiplexing," *Electronics*, vol. 25, pp. 146–148; December, 1952.

Also included within discussions of general problem were several variations of optimum linear detection.

(536) R. S. Berkowitz, "Optimum linear shaping and filtering networks," PROC. I.R.E., vol. 4, pp. 532–537; April, 1953.
(537) P. Rudnick, "The detection of weak signals by correlation methods," *Jour. Appl. Phys.*, vol. 24, pp. 128–131; Feb., 1953.
(538) H. Urkowitz, "Filters for detection of small radar signals in clutter," *Jour. Appl. Phys.*, vol. 24, pp. 1024–1031; August, 1953.

The Shannon sampling theorem, which relates a continuous time function to its sampled values, was extended to cover the important case of a signal with finite bandwidth not centered at zero frequency. Work was also done on the algebra of manipulating sequences of sampled values.

(539) A. Kohlenberg, "Exact interpolation of band-limited functions," *Jour. Appl. Phys.*, vol. 24; December, 1953.
(540) W. E. Thomson, "A theory of time series for waveform-transmission system," *Proc. IEE* (*London*), part 4, vol. 99, pp. 397–409; December, 1952.

Further studies of the technique, evaluation, and classification of coding were carried out.

(541) E. C. Cherry and G. G. Guriet, "Some possibilities for the compression of television signals by recoding," *Proc. IEE* (*London*), part 3, vol. 100, pp. 9–18; January, 1953.
(542) D. A. Bell, "'Ideal coding' versus 'Redundancy,'" *Wireless Eng.*, vol. 30, pp. 73–74; March, 1953.
(543) N. M. Blachman, "Minimum-cost Encoding of Information." Presented at Symposium on Statistical Methods in Communication Engineering, University of California; August, 1953.
(544) A. E. Laemmel, "Application of Linear Graphs to Communication Problems." Presented at Symposium on Statistical Methods in Communication Engineering, University of California; August, 1953.

The growing awareness of noise, as the basic limitation in any communication system, spelled out the need for uniform quantitative standards for noise. Similarly, definitions of terms dealing with modulation systems were determined.

(545) "Standards on modulation systems: definitions of terms, 1953," PROC. I.R.E., vol. 41, pp. 612–615; May, 1953.
(546) "Standards on electron devices: methods of measuring noise," PROC. I.R.E., vol. 41, pp. 890–896; July, 1953.

A number of articles surveying the field of modulation systems appeared. These indicate trends toward the use of time multiplexing over frequency multiplexing for advantages in size and weight of equipment; angle-modulated frequency-shift systems in telegraphy; single-sideband operation in a band type of modulation; and improved applications of exalted-carrier and single-sideband diversity receiving systems.

(547) A. J. Oxford, "Pulse-code modulation systems," PROC. I.R.E, vol. 41, pp. 859–865; July, 1953.
(548) L. M. Craft, "Design trends in communication equipment," TRANS. I.R.E., Professional Group on Communication Systems, vol. CS-1; July, 1953.
(549) R. M. Page, "Comparative study of modulation methods," TRANS. I.R.E., Professional Group on Communication Systems, vol. CS-1, pp. 13–32; July, 1953.
(550) I. S. Coggeshall, "Transmission of intelligence in typescript," TRANS. I.R.E., Professional Group on Communication Systems, vol. CS-1, pp. 4–12; July, 1953.

The need for a receiver which responds to both amplitude and phase modulation was shown. Restriction of the transmitted signal or the receiver response to either of these reduces the information capacity of the system below the full-channel capacity. It was found that at very high signal-to-noise ratios, the capabilities of AM alone, and of PM alone, each account for half of the information capacity of the channel. When the signal-to-noise ratio is much less than unity, however, PM uses 79 per cent of the full channel capacity. Specific results were also determined for other signal-to-noise ratios and types of operation.

(551) N. M. Blachman, "A comparison of the informational capacities of amplitude- and phase-modulation communication systems," Proc. I.R.E., vol. 41, pp. 748–759; June, 1953.

Error probabilities were computed for two practical systems: carrier-keyed systems and frequency-shift-keyed systems.

(552) S. Reiger, "Error probabilities of binary data transmission systems in the presence of random noise," *Convention Record of the I.R.E.*, part 8—Information theory, pp. 72–76; New York, March 23–26, 1953.

Work was done on timing, gating, summation, and coincidence-detection processes for pulse encoding and decoding with passive networks.

(553) K. F. Blake, "Pulse-group coding and decoding by passive networks," *Proc. N.E.C.* (Chicago), vol. 8, pp. 760–765; 1953.

New systems of pulse modulation were developed. The "ambiguous-index system," while it does not improve on the theoretical performance of the standard PCM system, was shown to have certain practical advantages and to permit a new and satisfactory classification of the system commonly called "pulsed frequency modulation."

New results were reported on "delta modulation" systems which were shown to be identical to systems quantized in time. A new encoder and methods for computing the distortion were developed. It was pointed out that a delta modulation system has inherent distortion of the derivative of the signal. In some cases this may be an advantage over PCM whose inherent distortion is in the signal itself. It was also shown that delta modulation is better than PCM for speech, in terms of bandwidth required for a given signal-to-quantizing noise ratio.

(554) C. W. Earp, "Recent developments in communication technique," *Elec. Commun.*, vol. 30, pp. 61–70; March, 1953.
(555) "Note on delta modulation," *Elec. Commun.*, vol. 30, pp. 71–74; March, 1953.
(556) H. van de Weg, "Quantizing noise of a single integration delta modulation system with an *N*-digit code," *Philips Res. Rep.*, vol. 8, pp. 367–385; October, 1953.

New techniques were developed for making statistical measurements. Included were methods for making noise studies on both linear and nonlinear time-varying systems, an analog device for continuous computation of short-time correlation functions, and a microwave correlator. In the latter, a method of frequency translation involving the generation of a line spectrum of local oscillator frequencies throughout the bandwidth of the signal was used to obtain a transformation of the spectrum into a more convenient form for measurement.

(557) R. R. Bennett, "Analog computing applied to noise studies," Proc. I.R.E., vol. 41, pp. 1509–1513; October, 1953.
(558) W. R. Bennet, "The correlatograph," *Bell Sys. Tech. Jour.*, vol. 32, pp. 1173–1185; September, 1953.
(559) R. M. Page, A. Brodzinsky, and R. R. Zirm, "A microwave correlator," Proc. I.R.E., vol. 41, pp. 128–131; January, 1953.

A word of caution against indiscriminate use of various new statistical approaches such as correlation functions was sounded.

(560) M. J. E. Golay, "Correlation versus linear transforms," Proc. I.R.E., vol. 41, pp. 268–271; February, 1953.

A great deal of attention was paid to the passage of noise through linear and nonlinear devices. The response of dynamic systems to completely or partially random inputs was determined analytically for special cases. Various papers summarized the methods which are known and extended and simplified the procedures.

(561) G. O. Yound and B. Gold, "Noise problems of theoretical and practical interest," *Convention Record of the I.R.E.*, part 8—Information theory, pp. 2–6; New York, March, 1953.
(562) A. J. F. Siegert, "Passage of Stationary Processes through Linear and Non-linear Devices." Presented at Symposium on Statistical Methods in Communication Engineering, University of California; August, 1953.
(563) B. Gold and G. O. Yound, "Response of Linear Systems to Non-Gaussian Noise." Presented at Symposium on Statistical Methods in Communication Engineering, University of California; August, 1953.
(564) D. B. Duncan, "Response of undamped systems to noise," *Jour. Appl. Phys.*, vol. 24, pp. 1252–1253; September, 1953.
(565) D. B. Duncan, "Response of linear time-dependent systems to random inputs," *Jour. Appl. Phys.*, vol. 24, pp. 609–611; May, 1953.
(566) R. C. Emerson, "First probability densities for receivers with square law detectors," *Jour. Appl. Phys.*, vol. 24, pp. 1168–1176; September, 1953.

Specific calculations of the noise in crystal mixers showed that there is an optimum intermediate frequency for minimum noise figure. A study of noise in microwave superregenerative defined the mode of operation for a minimum over-all noise figure.

(567) P. D. Strum, "Some Aspects of mixer crystal performance," Proc. I.R.E., vol. 41, pp. 875–889; July, 1953.
(568) T. S. George and H. Urkowitz, "Fluctuation noise in a microwave super-regenerative amplifier," Proc. I.R.E., vol. 41, pp. 516–521; April, 1953.

An interesting contribution to the fundamental theory of noise was a computation of the noise in a damped, oscillatory circuit on a quantum mechanics basis, using field quantization and perturbation theory to give an explicit treatment of the physical source of noise.

(569) J. Weber, "Quantum theory of a damped electrical oscillator and noise," *Phys. Rev.*, vol. 90, pp. 977–982; June 1, 1953.

In speech analysis and synthesis, the need was recognized for a quantitative measure of the effectiveness of the various methods of bandwidth reduction that have become established in past years.

A committee was organized to sift all the existing data and theories on speech analysis and synthesis. A figure of merit for speech-synthesis systems was formulated. A figure of merit of a system is the ratio of the slope of the curve of articulation index versus capacity to that of a standard curve representing a normal telephone system. On this basis figures of merit for the four equipments representative of the four distinct approaches to speech synthesis are: Vobanc, 2; Improved Dudley Vocoder, 10; Phonetic Vocoder 10 to 50; Formant Vocoder, 50. The theoretical upper limit, given by an optimally coded telegraph, is 500.

A symposium was held at the Massachusetts Institute of Technology in November. Papers presented at this meeting reviewed progress in each of the four engineering approaches to the problem of bandwidth reduction in the transmission of speech. A number of papers were also given at a meeting of the Acoustical Society of America in Philadelphia in May.

Navigation Aids

General

The problems of air navigation received increased attention during 1953. This is indicated by the attendance at two nationwide conferences devoted exclusively to the field. These were the IRE National Conference on Airborne Electronics at Dayton, Ohio, and the Classified Symposium on Airborne Electronics at Los Angeles, California.

(570) A. Van Dyck, "Aviation electronics," Proc. I.R.E., vol. 41, pp. 1572–1578; November, 1953.
(571) Radar and telemetry," *Convention Record of the IRE*, part 1; 1953.
(572) D. K. Martin, "Navigation," *Aviation Age*, vol. 19, p. 220; June, 1953.
(573) P. Klass, "AEEC acts on avionic problems," *Aviation Week*, vol. 59, p. 71; November, 1953.

Helicopter Navigation

Perhaps the newest problem to receive major attention was that of helicopter navigation. A project for the development and evaluation of facilities for helicopter navigation was undertaken by the Air Navigation Development Board. The wide range of ground speed, the modulation interference created by the rotating wings, and the unique approach path are matters of concern in the use of radar moving-target indicators, omnirange, and instrument landing systems. Some work was done also with CAA precision approach radar and a one-man radar talk down system.

(574) H. H. Hollister, Status Report of Helicopter Navigation Project 6.8; October 26, 1953.
(575) A. L. Comstock, "Raydist pinpoints 'copter blind landings," *Aviation Age*, vol. 19, pp. 30–31; March, 1953.

VOR/DME

The Civil Aeronautics Administration (CAA) commissioned the first segments of the "Victor Airways." (those providing actual operational use of the VHF Omnirange). They either parallel or supplement the original airways served by low- and medium-frequency radio ranges, which are to be discontinued. VOR facilities were installed in Holland, Liberia, England (Fairfield AFB), and Belgium bringing the total outside the U.S. to 17.

DME, operating at 1000 mc and used in conjunction with VOR and ILS, was commissioned at numerous locations. An early evaluation of DME on the New York-Chicago Airway was made in 1952 and additional demonstration flights were conducted during 1953, including one by CAA to evaluate DME in the Rocky Mountain area.

(576) J. R. Hoffman and R. E. Carlson, "Developments in DME Interrogator," CAA Report TD-212; June, 1953.
(577) "DME at Work," Civil Aeronautics Administration; September, 1952.
(578) F. Penin and G. Phélizon, "DME," *Onde Elec.*, vol. 33, pp. 309–318; May, 1953.
(579) "Airborne DME—what price accuracy?" *Aviation Age*, vol. 19, pp. 40–47; April, 1953.
(580) S. E. Poritzky, "Testing your DME," *Aviation Age*, vol. 19, pp. 36–39; May, 1953.

The cone of ambiguity over the VOR is considerably reduced by the use of only four instead of five Alford loops. All future installations will use four loops and existing facilities will be converted as funds become available. Additional designs and tests were conducted on a single cylindrical all-weather slot antenna for VORs.

(581) S. R. Anderson and W. A. Law, "Measurement of VOR Polarization Errors," CAA Report TD-202; May, 1953.
(582) Hoffman, Carlson, and Haworth, "Development of a DME Antenna Transfer Switch," CAA Report TD-201; May, 1953.

ILS

There are approximately 130 ILS installations operating in the United States and an additional 55 or more in foreign countries. Recent foreign installations were in Lima, Buenos Aires, Bombay, Karachi, Istanbul, and Milan.

A significant step forward in ILS was the beginning of installation of new null-reference glide-slope equipments by CAA. These equipments contain many improvements in design, in ease of maintenance, and in monitoring efficiency. However, the most significant improvement is in the antenna. The upper antenna is at a height at which a null is created in its vertical radiation pattern at the angle of the desired glide slope. The lower antenna fills in the null with equisignal (equal 90 and 150 cycle modulation) giving operation essentially the same as that of the ILS localizer, except in the vertical plane. There is remarkable improvement in stability of established glide slope angle under conditions of rain and snow. A problem in initial siting of facility is created because a larger smooth area of terrain is required for the null-reference system compared to that required for the previous equi-signal system.

(583) "Some Effects of Terrain on the Null-Reference Glide-Path Shape," Report by CAA (TD No. 169); August, 1952.

Radar

An airport surveillance radar (ARS-2) and a precision approach radar (PAR-2) were developed. Production prototype units were installed at Baltimore and Philadelphia, respectively, for evaluation. The major improvements over prior models were increased stability, ease of maintenance, and greater resolution. The new ASR-2 antenna provides a 2.5-degree horizontal beamwidth and a sharp bottom-pattern cutoff for discrimination against ground clutter.

A system for remote reproduction of radar displays was shown to the public. This system, Rafax, makes possible the transmission of PPI information over ordinary telephone circuits and also permits recording on magnetic tape.

(584) J. L. McLucas, "Rafax bandwidth compressor and airport-traffic-control recorder." Presented at IRE Princeton Section Meeting, Princeton, N. J.; November 12, 1953.
(585) E. Roessler, "A special type of pulse modulation for transmission of radar pictures (sampling)," *Fernmeldetech. Z.*, vol. 6, pp. 78–79; February, 1953.

Tests of airborne radar conducted by a commercial airline of interest because they revealed that all storm areas of consequence were always visible 10 miles in advance and that the equipment operated satisfactorily three months without retuning.

(586) "Airborne radar tests by U.A.L.," *Aviation Week*, vol. 59. p. 72; November 16, 1953.
(587) F. R. Dickey, Jr., "Theoretical performance of airborne moving target indictor," TRANS. I.R.E., *Prof. Group on Airborne Electronics* (vol. PGAE-8, p. 12; June, 1953.
(588) T. S. George, "Fluctuations of ground clutter return in airborne radar equipment," *Proc. IEE* (*London*), part 4, vol. 99, pp. 92–99; April, 1952.

Two one-man radar talk-down systems were developed in England. One of these consists of a radar equipment pivoted at its base and having an overhead antenna secured to it. The operator observes targets on an A-type display, turning the entire equipment in azimuth and tilting the antenna in the vertical plane to maximize the pencil-beam signal on the target. Maximum range is 15 nautical miles. A simple vhf/df antenna is attached to the radar dish to assist in vectoring the aircraft into suitable position for control by radar.

(589) A. C. Belcher and E. F. Mackey, "Flight Evaluation of One-Man Radar Talk-Down System," Prob. 53-10(825), U. S. Naval Air Testing Center, Patuxent River, Md., September, 1953.

Loran

Automatic synchronization of Loran slave stations was implemented in 1953. This permits more economical operation since facilities can be left unattended. Automatic airborne equipment which provides continuous indication of position was introduced. Loran stations operating on the U.S. west coast were increased in power to 1 megawatt.

(590) R. B. Williams, "Continuously indicating Loran navigation," *Electronics*, vol. 26, pp. 166–169; July, 1953.

Decca

A new chain of Decca stations was placed in operation in central France. Arrangements were made for investigation of Decca as an aid in helicopter navigation between airports in the New York area.

Navarho

"Navarho," a combination of Navaglobe and a distance measuring system, was demonstrated in part. Navaglobe provides lines of position for lateral guidance. DME compatible with Navaglobe was not available until the development of a crystal clock that can be carried by a vehicle and be perfectly synchronized with a similar device at the Navaglobe station. In operation, the station transmits four pulses per second, one of these being a reference and the others being a pulse for each pair combination in a group of three spaced antennas. Azimuth information to a reported accuracy of 0.5 degree at 2,000 nautical miles is obtainable by comparison of the amplitudes of the 3 pulses. The fourth pulse provides identification and distance information.

The crystal clocks in both the station and the vehicle have a 24-hour stability of 1 part in 10^9. Comparison of received and local signals in the vehicle give distance information accurate to 1 per cent of the distance.

A subcommittee (SC-67) of the Radio Technical Committee for Aeronautics (RTCA) was set up to study operational requirements for long-distance navigational aids.

Computers in Navigation

A number of computer developments were reported. Pictorial computers were designed to display positional information continuously for the direct use of the pilot. VOR and DME signals operate other computers for use on the Federal Airways System.

A magnetic storage drum and accessories were developed for nationally co-ordinated control of air traffic, with the possible inclusion of weather information.

(591) S. E. Poritzky, "Pictorial computer simplifies navigation," *Aviation Age*, vol. 20, pp. 42–46; August, 1953.
(592) J. H. McGuigan, "Combined reading and writing on a magnetic drum," PROC. I.R.E., vol. 41, pp. 1438–1444; Oct., 1953.
(593) "Drum storage for flight data," *Aviation Age*, vol. 2, pp. 56–59; November, 1953.

Communications

A simple selective calling system, Selcall, was developed. It uses two spaced tone-modulated pulses to actuate selective circuits in the aircraft and signal to the pilot by light or buzzer. By adjustment of the airborne equipment, it is made responsive to only one combination of frequency and spacing of tone pulses.

(594) P. Klass, "AEEC acts on avionic problems," *Aviation Week*, vol. 59, p. 71; November 16, 1953.

In London, the new Civil Aviation Communication Center was established for service to member states of the International Civil Aviation Organization (ICAO). This center is a fixed telecommunications network at Croydon Airport with circuits extending to all parts of the world.

(595) "Civil aviation communications centre," Civil Aviation Radio News Letter No. 16, Cerca Central Office, London; June 15, 1953.
(596) "New civil aviation communications centre," *Electronic Engineering* (*London*), p. 124; March, 1953.

Miscellaneous

(597) H. P. Kalmis, J. C. Kacheris, and H. A. Dropkin, "Nonquantizied, frequency modulation altimeter," *Jour. Res. Nat. Bur. Stand.*, p. 215; April, 1953.
(598) E. H. Fritze, "Punch-card controlled aircraft navigational computer," PROC. I.R.E., vol. 41, pp. 734–742; June, 1953.
(599) P. Klass, "Vibragyro takes cue from housefly," *Aviation Week*, vol. 59, p. 57; November 23, 1953.
(600) "Radio rescue beacon," *Wireless World*, vol. 59, pp. 381–382; August, 1953.

Electroacoustics

General Acoustics

The theory of acoustics has been steadily expanded in many directions during 1953.

An analysis of elastic wave propagation in a medium consisting of closely packed solid particles immersed in a fluid was carried out using the macroscopic approach.

(601) R. W. Morse, "Acoustic propagation in granular media," *Jour. Acous. Soc. Amer.*, vol. 24, pp. 696–700; Nov., 1952.

Streaming phenomena were investigated.

(602) P. J. Westervelt, "The theory of steady rotational flow generated by a sound field," *Jour. Acous. Soc. Amer.*, vol. 25, pp. 60–67; January, 1953.
(603) W. L. Nybord, "Acoustic streaming due to attenuated plane waves," *Jour. Acous. Soc. Amer.*, vol. 25, pp. 68–75; Jan., 1953.

An improvement on earlier theories dealing with the attenuation of sound in fog resulted in satisfactory agreement with experimental data.

(604) P. S. Epstein and R. R. Carhart, "The absorption of sound in suspensions and emulsions: I. Water fog in air," *Jour. Acous. Soc. Amer.*, vol. 25, pp. 553–565; May, 1953.

An interesting application of sound waves to atmospheric studies was reported. The reception of shock waves from a TNT explosion by means of hot-wire microphone arrays operating in the frequency range 5–13 cps gives information from which wind and temperature conditions at various altitudes can be calculated.

(605) J. M. Richardson and W. B. Kennedy, "Atmospheric winds and temperatures to 50 kilometers altitude as determined by acoustical propagation studies," *Jour. Acous. Soc. Amer.*, vol. 24, pp. 731–741; November, 1952.

An acoustic gyrator which is analogous to the microwave gyrator has been developed. The device operates by the mechanism of propagating a transverse wave down a rotating tube.

(606) W. E. Koch, "An acoustic gyrator," *Jour. Acous. Soc. Amer.*, vol. 25, p. 575; May, 1953.

Room Acoustics

A number of problems in room acoustics were studied by means of scale models using frequencies in the low ultrasonic range. These included sound transmission through partitions, and the effects of surface treatments and from hollow wall panels on reverberation.

(607) A. Schoch and K. Feher, "The mechanism of sound transmission through single-leaf partitions, investigated using small-scale models," *Acustica*, vol. 2, pp. 189–204; 1952.
(608) E. Meyer and L. Bohn, "Reflection of sound at surfaces with periodic structure," *Akus. Beihefte*, no. 4, pp. 196–207; 1952.
(609) F. Canoe, "Measurement of the reflecting power of ceilings, using ultrasonics," *Compt. Rend.* (*Paris*), vol. 236, pp. 467–469; February 2, 1953.

The use of resonant cavities as sound absorbers received considerable attention. Several forms were developed for broadcasting studios.

(610) F. L. Ward, "Helmholtz resonators as acoustic treatment at the new Swansea studios," *BBC Quart.*, vol. 7, pp. 174–180; Autumn, 1952.
(611) C. L. S. Gilford, "Membrane sound absorbers and their application to broadcasting studios," *BBC Quart.*, vol. 7, pp. 246–256; Winter, 1952–1953.

The low-frequency absorption of an anechoic chamber was enhanced by combining damped Helmholtz resonators with the usual wedge-shaped absorbers.

(612) H. Ebal and P. Mauer, "New anechoic chamber of the Technische Hochschule, Karlsruhe," *Akus. Beihefte*, no. 4, pp. 253–256; 1952.

Loudspeakers

While no fundamentally new developments were reported, the demand for superior loudspeakers in connection with FM broadcasting and record players continued to grow. Improved loudspeakers employing 2, 3, and even 4 units to cover the audio range as well as wide range single unit types were made available.

A theoretical and experimental investigation of the air chamber in horn loudspeakers was carried out for the cases where the horn throat enters the chamber by means of a single orifice, a single annulus or a number of annuli. By the suitable choice of radii and widths of "m" annuli, an equal number of the high-frequency chamber resonances can be suppressed, and a smooth response obtained.

(613) B. H. Smith, "An investigation of the air chamber of horn type loudspeakers," *Jour. Acous. Soc. Amer.*, vol. 25, pp. 305–312; March, 1953.

A modern version of a friction-driven loudspeaker was developed in a commercial form. The diaphragm is actuated from a metal band held in contact with a rotating cylinder which is coated with a semiconductor. The attraction between the band and cylinder varies with the applied voltage.

(614) "Friction-driven loudspeaker," *Wireless World*, vol. 59, pp. 27–28; January, 1953.

Microphones

Steady improvement took place in microphone design, based on established transducer principles. To meet needs of television studios as well as other applications, microphone size is being reduced, directional discrimination and ruggedness is being improved.

(615) H. F. Olson, J. Preston, and J. C. Bleazey, "The uniaxial microphone," *RCA Rev.*, vol. 14, pp. 47–63; March, 1953.
(616) J. Medill, "A miniature piezoelectric microphone," *Jour. Acous. Soc. Amer.*, vol. 25, pp. 864–866; September, 1953.

Underwater Sound

Two methods of absorbing underwater sound waves were developed. In one case rubber sheets containing cylindrical air cavities, and backed by steel plates, were found to have energy absorption values of over 99 per cent in the frequency range 9–18 kc. In another case, absorbers were designed for 5–50 kc using porous elastic-rubber materials and having ribs arranged to form parallel ducts with sloped walls for impedance matching:

(617) E. Mayer and H. Oberst, "Resonance-type absorbers for water-borne sounds," *Akus. Beihefte*, no. 3, pp. 149–170; 1952.
(618) E. Mayer and K. Tamm, "Wide-band absorbers for liquid-borne sound," *Akus. Beihefte*, no. 2, pp. 91–104; 1952.

The problem of detecting underwater sound in presence of noise created by surface waves was investigated. Results are given in terms of directivity factor of hydrophone, bandwidth, and operating noise factor.

(619) R. H. Mellen, "Thermal noise limit in the detection of underwater acoustic signals," *Jour. Acous. Soc. Amer.*, vol. 24, pp. 478–480; September, 1952.

Ultrasonics

In this active field, many new techniques of measurement have been developed while old ones were refined. Barium titanate transducers were fabricated that can generate very high intensities by their focussing action.

(620) H. D. Parbrook, "An acoustic interferometer for high fluid pressure," *Acustica*, vol. 3, pp. 49–54; 1953.
(621) G. Kurtz and K. Tanim, "Measurements of sound absorption in water and in aqueous solutions of electrolytes," *Acustica*, vol. 3, pp. 33–48; 1953.
(622) O. Mattiat, "Transducers for producing ultrasonic waves," *Jour. Acous. Soc. Amer.*, vol. 25, pp. 291–296; March, 1953.

The papers from the 1952 symposium held in May, 1952 on ultrasound in biology and medicine were published. They are exploratory in nature and deal with the effects of ultrasound on various types of tissue. Nerve cells were found to be particularly susceptible to damage, an effect that is not explainable as the result of either cavitation or heating.

(623) "Symposium on ultrasound in biology and medicine," *Jour. Acous. Soc. Amer.*, vol. 25, pp. 1–25; January, 1953.
(624) J. J. Wild and J. M. Reid, "The effects on biological tissues on 15-mc pulsed ultrasound," *Jour. Acous. Soc. Amer.*, vol. 25, pp. 270–280; May, 1953.
(625) P. D. Wall, D. Tucker, F. J. Fry, and W. H. Mosberg, Jr., "The use of high intensity ultrasound in experimental neurology," *Jour. Acous. Soc. Amer.*, vol. 25, pp. 281–285; May, 1953.

The effects of ultrasound in chemistry also received considerable attention. A number of interesting electrochemical effects have been studied as well as direct effects on chemical reactions due to cavitation.

(626) "Symposium on acoustics and chemistry," *Jour. Acous. Soc. Amer.*, vol. 25, pp. 443–490; May, 1953.
(627) A. Weissler, "Sonochemistry: The production of chemical changes with sound waves," *Jour. Acous. Soc. Amer.*, vol. 25, pp. 651–657; July, 1953.
(628) G. W. Willard, "Ultrasonically induced cavitation in water: a step-by-step process," *Jour. Acous. Soc. Amer.*, vol. 25, pp. 669–686; July, 1953.

A number of industrial applications were reported, including a method of degreasing, a machine tool for cutting hard brittle materials such as ceramics and tungsten carbide, and a method of measuring viscosities.

Physiological and Psychological Acoustics

The importance of subjective tests on loudspeakers as a check on objective measurements was emphasized in two recent articles. Suitable procedures for making various types of determinations such as per cent nonlinear distortion, loudness efficiency and desirable frequency range are discussed.

(629) F. H. Brittain, "Loudspeakers: relations between subjective and objective tests," *Jour. Brit. I.R.E.*, vol. 13, pp. 105–109; February, 1952.
(630) H. F. Olson, "Subjective loudspeaker testing," Trans. I.R.E.-PGA, vol. UA-1, pp. 7–9; September–October, 1953.

The effects of nonlinear distortion in transmission systems for music have been studied in a series of listening tests. With two-toned musical fifths, second harmonic distortion was noticeable when a few parts per hundred were present whereas third harmonic distortion became evident with only a few parts per thousand. It was also found that harmonics created by nonlinearity enhanced perception of errors of intonation.

(631) R. Feldtkeller, "The perception of non-linear distortion in the transmission of musical two-tone combinations," *Akus. Beihefte*, no. 3, pp. 117–124; 1952.

Control and Measurement of Acoustic Noise

Various devices such as flexible couplings, isolating hangers and other damping treatments for the reduction of noise transmitted through piping were studied. Broadband noise in the audible range was introduced into the pipe and its contents, and vibration measurements were made by the use of an accelerometer.

(632) D. B. Calloway, F. G. Tyzzer, and H. C. Hardy, "Techniques for evaluation of noise-reducing piping components," *Jour. Acous. Soc. Amer.*, vol. 24, pp. 725–730; November, 1952.

A series of papers covering the generation, propagation, and control of aircraft noise presented in 1952 were published this year.

It was found that propeller noise can be lowered markedly by increasing the number of blades and by using larger diameters to reduce tip speeds. These measures entail a serious increase in weight, which is offset at high airplane speeds by an increase in efficiency.

Several papers describe construction of enclosures for testing various types of aircraft engines and ground testing a complete jet airplane. With noise levels of 140 db in testing cell, maximum levels of 100 db for test operators, 85 db for nearby workers and 60 db for neighbors at distance of several thousand feet were achieved. Attenuation in structure and through intake and exhaust ducts run as high as 50 db for middle audio range.

(633) "Symposium on aircraft noise," *Jour. Acous. Soc. Amer.*, vol. 25, pp. 363–442; May, 1953.

Vehicular Communications

The number of mobile units used in the land-transportation, public-safety, common-carrier, and industrial fields increased about 8 per cent during 1953. At the end of the year, common-carrier mobile telephone service was available in 180 cities, serving more than 13,500 mobile stations through 285 base stations in the 30–50 mc and 152–162 mc bands, and a total of 21 trains provided mobile telephone service for their passengers.

The Joint Technical Advisory Committee, after more than a year of intensive study and field tests, submitted to the Federal Communications Commission a report dated May 28, 1953 on Land-Mobile Channeling Assignments, discussing spectrum utilization in the mobile frequency bands. This report indicated that channel splitting in the 152–174 mc band was technically feasible and two plans were presented; one suggested reducing the channel bandwidth from 60 to 30 kc, and the other proposed that the bandwidth be reduced to 20 kc but that channel assignments be made on an alternate (40 kc) basis in the same area. Further reference to split channel operation is contained in the section of this report on Radio Transmitters.

There was a great increase in the occupancy of the 450–460 mc band by land-mobile services. Many organizations ineligible under existing regulations for other bands have turned to the 460–470 mc Citizens Radio band. Approximately 2,500 mobile units and 400 base stations were licensed for operation by the end of 1953.

Extensive use of 12-volt electrical systems in vehicles resulted in development of interchangeable power supplies for mobile radio sets to permit operation from either 6- or 12-volt systems.

Increased attention was given to the integration of mobile systems with microwave and other point-to-point radio links and networks.

(634) J. R. Neubauer, "Integrating microwave and mobile radio systems." Presented at Meeting of IRE Professional Group on Vehicular Communications, Boston, Mass.; November, 1953.
(635) M. G. Steele, "Maintenance of mobile equipment." Presented at Meeting of IRE Professional Group on Vehicular Communications, Boston, Mass.; November, 1953.
(636) G. E. Dodrill, "Mobile and fixed radio relay operation in the power radio service." Presented at Meeting of IRE Professional Groups on Vehicular Communications, Boston, Mass.; November, 1953.
(637) D. E. York, "Problems in maintenance and operation of long-haul and distribution radio networks." Presented at Meeting

of IRE Professional Group on Vehicular Communications, Boston, Mass.; November, 1953.

(638) W. J. Young, "Planning and operation of the Erie railroad main line radio communications system." Presented at Meeting of IRE Professional Group on Vehicular Communications, Boston, Mass.; November, 1953.

Radio Transmitters

Television Broadcasting

The number of television stations operating in the United States more than doubled during 1953; from 125 (5 uhf) to 356 (122 uhf). A set of signal specifications was evolved for color broadcasting:

(639) National Television System Committee, "Report of Panel 17, broadcast system," NTSC-P17-379; July 31, 1953.

(640) National Television System Committee, "Petition of National Television System Committee for adoption of transmission standards for color television," NTSC-G-378; July 21, 1953.

(641) R. D. Kell and D. C. Schroeder, "Optimum utilization of the radio frequency channel for color television," *RCA Rev.*, vol. XIV, pp. 133–143; June, 1953.

(642) "Technical signal specifications proposed as standards for color television," *RCA Rev.*, vol. XIV, pp. 359–366; June, 1953.

The Federal Communications Commission ordered changes in rules governing several radio services including a tightening of frequency tolerances in the aeronautical services and reduction in the permissible out-of-band radiation in television broadcasting.

(643) "Amendment of sections 9.172 and 9.446 of the Commission's rules and regulations governing aeronautical services," FCC Docket 10448; July 15, 1953.

(644) "Amendment of Part 3 (Radio Broadcast Services)," FCC Docket 10369; April 22, 1953.

(645) "Amendment of Section 3.687 (i) (1) of the Commission's rules governing television broadcasting stations," FCC Docket 10353; June 10, 1953.

(646) "Amendment of Part 3 of the Commission's rules and regulations to effectuate the Commission's CONELRAD plan for broadcast stations," FCC Docket 10420; April 8, 1953.

(647) "Amendment of Part 19 of the Commission's rules and regulations governing the Citizens Radio Service," FCC Docket 10545; August 7, 1953.

(648) "Title 47 Telecommunication, Chapter 1—Federal Communications Commission—Part 3—Radio Broadcast Services," *Federal Register*, vol. 18, pp. 3834–3910; July 4, 1953.

Television broadcasting in other countries showed increasing activity during the year.

(649) "Television from Venezuela," *Marconi Rev.*, vol. XV, no. 106, p. 138; 3rd quarter, 1952.

(650) "New B.B.C. television installations," *Marconi Rev.*, vol. XV, no. 106, pp. 138–139; 3rd quarter, 1952.

(651) "Television programmes from France," *Marconi Rev.*, vol. XV, no. 106, p. 139; 3rd quarter, 1952.

(652) "First television network in Canada," *Marconi Rev.*, vol. XV, no. 106, pp. 186–187; 4th quarter, 1952.

(653) P. A. T. Bevan, "The 100-kw E. R. P. Sutton Coldfield television broadcasting station," Proc. I.R.E., vol. 41, pp. 196–218; February, 1953.

(654) P. A. T. Bevan, "Television broadcasting stations," *Proc. IEE*, vol. 99, Pt. 3A, no. 18, pp. 179–214; 4th quarter, 1952.

The opening of the uhf region for television broadcasting stimulated work on tubes for the new band and power outputs as high as 1,200 watts and 900 mc were reported.

(655) L. L. Koros, "Measurements of some operational characteristics of an amplitude-modulated injection-locked uhf magnetron transmitter," Proc. I.R.F., vol. 4, pp. 4–10; April, 1953.

(656) W. P. Bennett and H. F. Kazanowski, "One-kilowatt tetrode for uhf transmitter," Proc. I.R.E., vol. 41, pp. 13–19; January, 1953.

(657) C. L. Cuccia, "The electron coupler—a developmental tube for amplitude modulation and power control at ultra-high frequencies," *RCA Rev.*, vol. XIV, pp. 72–99; March, 1953.

A British television test equipment was described by which a comprehensive pattern on all BBC channels is distributed to testing points simultaneously.

(658) J. M. Silberstein, "A transmitter for production testing of television receivers," *Electronic Eng.*, vol. XXV, No. 304, pp. 224–229; June, 1953.

There was some literature dealing with transmitter design and techniques.

(659) J. M. Baldwin, "Mountain top transmitter station" (Television transmitter station), *TV and Radio Eng.*, vol. 23, pp. 12–14, 36; April–May, 1953.

(660) V. J. Cooper, "A comparison of high level with low level modulation for television transmitters," *Marconi Rev.*, vol. XV, no. 106, pp. 118–137; 3rd quarter, 1952.

(661) T. M. Gluyas and E. H. Potter, "TTU-1B 1-kw uhf tv transmitter," *Broadcast News*, vol. 74, pp. 22–31; May–June, 1953.

Microwave Communications

Steady progress in this field included many new designs for microwave equipment. Applications of line-of-sight equipment increased.

(662) N. B. Tharp, "A new set of equipment for a new art—microwave communication," *Westinghouse Eng.*, pp. 198–203; November, 1952.

(663) N. B. Tharp, "New multiplex microwave system," *Commun. Eng.*, vol. 13, pp. 31–34, 39; March–April, 1953.

(664) E. Dyke, "Design features of a microwave relay, Part 1," *Tele-Tech.*, vol. 11, pp. 54–57, 1454; December, 1952 and "Part 2," vol. 12, pp. 60–63, 1364; January, 1953.

(665) J. R. Rae, "Microwaves from coast-to-coast," *GE Rev.*, vol. 56, pp. 17–22; March, 1953.

(666) C. A. Andreasson, "Microwave links for ppwer plant operation," *Teknisk Tidskrift*, vol. 83, pp. 381–385; May 5, 1953.

(667) R. D. Boadle, "Multichannel microwave relay system," *Proc. I.R.E. (Australia)*, vol. 14, pp. 80–89; April, 1953.

(668) R. E. Lacy and C. E. Sharp, "FM microwave radio relay," Proc. I.R.E., vol. 41, pp. 125–128; January, 1953.

Expansion of the microwave communication field brought the inevitable investigation of propagation problems.

(669) P. L. Rice, W. V. Mansfield, and J. W. Hertstreit, "Ground to air cochannel interference at 2.9 kmc/s;" Dec., 1953.

(670) L. J. Libois, "Equipment for testing propagation on 8 cm wavelength," *Echo des Recherches*, no. 9, pp. 2–6; Oct., 1952.

Common-Carrier Radio Relay

An intensive program to develop and install relay equipment for general communications and television relaying was carried out in Germany.

(671) P. Barkow, "Transmission measurements of ppm radio relay systems," *Fernmeldetech. Z.*, vol. 6, pp. 2–11; January, 1953.

(672) E. Schulz et al., "Radio link system with pulse-phase modulation for transmitting 12 and 24 telephone channels," *Fernmeldetech. Z.*, vol. 5, pp. 456–467; October, 1952.

(673) K. O. Schmidt, "Present state of development of radio link equipment and plans for radio links in the German Federal Republic" (In German), *Fernmeldetech. Z.*, vol. 6, pp. 51–58; February, 1953.

Israel and Norway have installed common-carrier relay systems.

(674) L. C. Simpson, "Israel intercity vhf telecommunication systems," *RCA Rev.*, vol. XIV, no. 1, pp. 100–124; March, 1953.

(675) "Wireless communications in Norway," *Marconi Rev.*, vol. XV, no. 107, pp. 185–186; 4th Quarter, 1952.

Television Relaying

The principal new activity in this field was in England and Germany. Several uhf and some microwave equipments were described.

(676) O. H. Appelt, K. Christ, and K. Schmid, "UHF television relay link Cologne-Frankfurt-Neustadt," *Fernmeldetech. Z.*, vol. 6, pp. 406–410; August, 1953.
(677) K. O. Schmidt, "High frequency apparatus used in the TV Relay Hamburg-Cologne," *Fernmeldetech. Z.*, vol. 6, pp. 226–230; May, 1953.
(678) W. Scholz, "Ultra high frequency radio link for television program exchange between Hamburg and Berlin," *Fernmeldetech. Z.*, vol. 5, pp. 539–544; December, 1952.
(679) G. Dawson, "Portable equipment for a microwave television link," *Proc. IEE (London)*, vol. 99, pt. 3A, no. 18, pp. 379–384; 1952.
(680) H. Faulkner, "Permanent point-to-point links for relaying television," *Proc. IEE (London)*, vol. 99, pt. 3A, no. 18, pp. 313–322; 4th quarter, 1952.
(681) F. W. Cutts, "Mobile high-power microwave link for vision and sound," *Proc. IEE (London)*, vol. 99, pt. 3A, no. 18, pp. 374–378; 4th quarter, 1952.

International Broadcasting and Communications

Emphasis continued on high power for broadcasting and single-sideband operation for communications. Strong trend toward quick frequency change and automatic tuning methods was in both types. Suppression of harmonic outputs assumed increasing importance.

(682) A. G. Robeer, "100 kw short-wave broadcast transmitter," *Communication News*, vol. 13, pp. 22–40; February, 1953.
(683) C. J. Starner, "Type BHF-50A 50 kw high frequency transmitter," *Broadcast News*, vol. 72, pp. 58–65; January–February, 1953.
(684) E. Meinel, "Methods of operation of modern single sideband telephone transmitters" (In German), *Fernmelde Praxis*, vol. 29, no. 15, pp. 506–508; August, 1952.
(685) E. Meinel, "Mode of operation of the 20 kw single sideband telephone transmitters of the firm of C. Lorenz" (In German), *Fernmelde Praxis*, vol. 29, no. 19, pp. 646–648; October, 1952.
(686) N. F. Schlaack, "Single sideband system for overseas telephony," *Electronics*, vol. 24, pp. 146–149; November, 1952.
(687) K. Freudenhammer, "Harmonic power transmitted through the antenna from the output stage of a transmitter" (In German), *Fernmeldetech. Z.*, vol. 6; April, 1953.
(688) F. C. Owen and A. B. Ewen, "Single-sideband and multichannel operation of short-wave point-to-point radio-links—Part 2," *P. O. Elec. Eng. Jour.*, vol. 45, part 4; January, 1953.
(689) L.'t Hart and C. Strasser, "Modern transmitting equipment for mercantile-marine vessels," *Communication News*, vol. XIII, no. 2, pp. 50–60; April, 1953.
(690) T. D. Hobart, "Navy vlf transmitter will radiate 1,000 kw," *Electronics*, vol. 25, pp. 98–101; December, 1952.

AM Broadcasting

Major development activity in this field was outside of the United States. Work continued on paralleling transmitters, developing remotely controlled unattended transmitters, and on higher powers.

(691) A. R. A. Rendall and G. A. Hunt, "Transmitter combining circuits," *Electronic Eng. (London)*, vol. XXIV, no. 298, pp. 550–552; December, 1952.
(692) V. E. Hughes, "Remote controlled broadcast transmitter," *Electronics*, vol. 25, pp. 238, 242; October, 1952.
(693) H. Campet, "New 150 kw medium frequency radio transmitter" (In French), *Ann. Radioélec.*, vol. 7, pp. 139–150; April, 1952.
(694) W. J. Marcom, "Unattended broadcasting transmitters," *Marconi Rev.*, vol. XIV, no. 110, pp. 134–140; 3rd quarter, 1953.

Mobile Transmitters

New applications and expansion of existing fields accounted for a large amount of activity.

(695) "Automatic radio transmitter for lifeboats, *Engineering*, vol. 175, p. 479; April 10, 1953.
(696) D. J. Spooner, "Some problems encountered in the design of marine transmitters," *Brit. IRE Jour.*, vol. 13, pp. 325–330; June, 1953.
(697) L.'t Hart and C. Strasser, "Modern transmitting equipment for mercantile-marine vessels," *Communication News*, vol. 13, no. 2, pp. 50–60; April, 1953.
(698) J. H. Durrer, "New developments in army mobile communication equipment," TRANS. I.R.E. *PGVC-2*, pp. 24–32; August, 1952.
(699) L. S. Lappin and E. C. Mason, "Compact radio transmitter," *Elec. Manufacturing*, vol. 50, pp. 102–105; August, 1952.
(700) P. Klass, "Novel design featured in Collins hf transceiver," *Aviation Week*, vol. 57, p. 48; September 15, 1952.
(701) "Hand-carried 2-way FM equipment," *Communications Eng.*, vol. 13, pp. 28–30; March–April, 1953.
(702) K. Behr and H. Norrby, "Portable field radio equipment SUF-21K," *Ericcson Rev.*, no. 1, pp. 22–28; 1952.
(703) M. H. Dunbrack, "10-meter walkie-talkie," *Radio-Electronics*, vol. 23, pp. 94, 96; October, 1952.
(704) C. F. Maass and R. R. Reilly, "VHF-UHF rescue transceivers," *Tele-Tech*, vol. 11, pp. 67–69, 168–174; Sept., 1952.
(705) L. C. Watkins, Jr., "Multi-band V.F.O. mobile transmitter," *Radio and Telev. News*, vol. 48, pp. 39–43; December, 1952.
(706) C. V. Chambers, "Eight-band mobile transmitter," *QST*, vol. 37, pp. 11–16; May, 1953.
(707) J. B. Ferguson, "Mobile radio equipment design," *Commun. Eng.*, vol. 13, pp. 30–31, 48; May–June, 1953.

Theoretical and test data showed that transmitter extra-sideband energy can be reduced by using a low-pass audio filter ahead of the modulator. This seemed to be necessary for split-channel operation.

Equipment for split-channel operation in the range 152–174 mc was made available. A practical frequency tolerance of ±0.005 per cent was considered the "tightest" that could be achieved at reasonable cost with existing techniques.

(708) Joint Technical Advisory Committee, "Report of the JTAC Subcommittee on Land Mobile Channeling Arrangements," May 28, 1953. Available for reference at I.R.E. Headquarters.

Electronic Computers

Systems

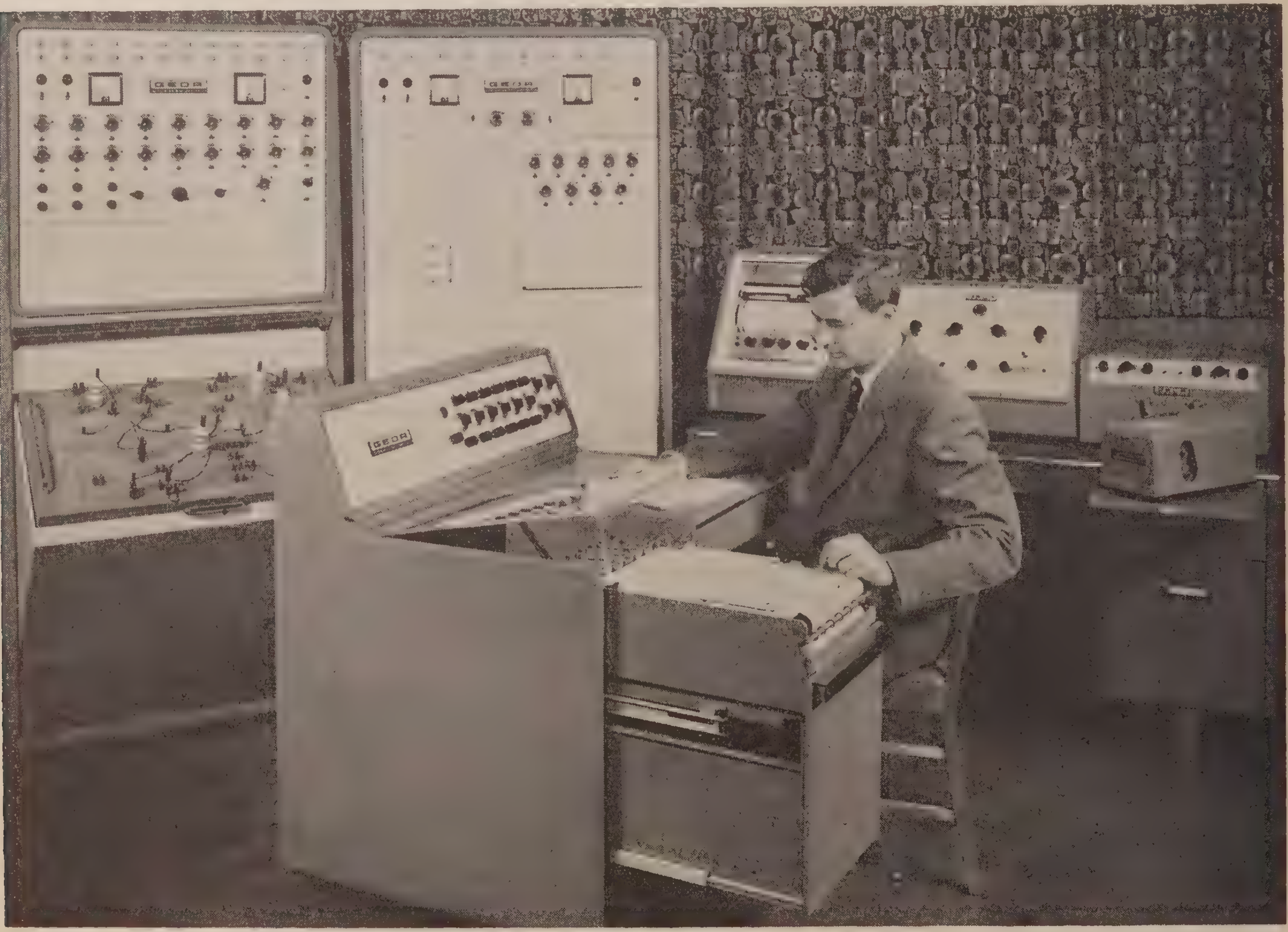
The production of commercial large-scale electronic digital computers for scientific and engineering applications was an impressive step in the progress of the still-rapidly-expanding electronic computer field.

The first production model of the type-701 computer was exhibited in New York during March. This is a parallel binary computer designed primarily to solve large problems in scientific and engineering computation. The computer is controlled by a stored program of single-address instructions. It has a large internal electrostatic storage with a capacity of 2,048 words each having 36 bits. This storage is supplemented by four units of magnetic-drum storage, each with a capacity of 2,048 words. The system includes a complete set of input-output components, including magnetic-tape units, punched cards, and a line-at-a-time printer. The 701 combines high storage capacity and fast input and output with high-speed operation. Addition time is 60 microseconds and multiplication time 456 microseconds. Although specifically designed to tackle problems that extend beyond the range of existing computers, the versatility of the input-output permits the 701 to be used efficiently on small problems that may occur in large numbers in an organization with central computing facilities. A number of these machines were installed throughout the country.

(709) W. Buchholz, "The system design of the IBM type 701 computer," Proc. I.R.E., vol. 41, pp. 1262–1275; October, 1953.

(710) C. E. Frizzell, "Engineering description of the IBM type 701 computer," Proc. I.R.E., vol. 41, pp. 1275–1287; October, 1953.

(711) H. D. Ross, "The arithmetic element of the IBM type 701 computer," Proc. I.R.E., vol. 41, pp. 1287–1294; October, 1953.



A group of commercial analog-computing equipment used for the first time in 1953. The units shown are manufactured by the Goodyear Aircraft Corporation, Akron, Ohio.

A new general-purpose computer system, the ERA 1103, was designed for scientific and control applications requiring large storage capacity, high operating speed, and great programming versatility. The internal memory consists of 1,024 registers of high-speed electrostatic storage and 16,384 registers of medium-speed magnetic-drum storage, all individually addressed. They are supplemented by magnetic-tape storage of optional capacity. A number of unconventional features in the internal logic of the machine bring about an efficient utilization of its inherent high speed. The computer terminal equipment includes punched cards, punched tape, and magnetic tape. A diversity of additional external units can be employed, including communication links and on-line instrumentation.

(712) W. G. Welchman, "Storage class control in the ERA 1103," Association for Computing Machinery, Cambridge, Massachusetts, September 10, 1953.

(713) A. E. Roberts, "Matrix multiplication on the ERA 1103," Association for Computing Machinery, Cambridge, Massachusetts, September 9, 1953.

Several UNIVACs were installed for scientific and business computation. The designers credit the low maintenance time required to the very complete checking devices built into the machine. Marginal checking facilities were also added and three new auxiliary devices were designed. The first is a self-checking card-to-tape converter; the second is a high-speed printer using magnetic tape-recorded input; and the third is a new keyboard-to-tape transcriber that is much simpler than the original model Unityper.

(714) J. R. Weiner, "Operating experience with UNIVAC systems," *The Transactions of the I.R.E. Professional Group on Electronic Computers*, vol. PGEC-1, pp. 33–46; December, 1952.

The type 650 is a general-purpose electronic computer intermediate in speed, capacity, and cost. The magnetic drum used for internal memory rotates at 12,500 rpm and stores 1,000 to 2,000 words, ten decimal digits in length plus sign. Hollerith code is used on the punched-card input and output, a special five-pulse code is used for recording on the drum, and a biquinary code is used in the rest of the computer. Many other small commercial general-purpose electronic digital computers are available or are being developed; these include MONROBOT, CADAC, Circle Computer, ELFCOM 100, Model 30-201, and the MINIAC.

(715) F. E. Hamilton and E. C. Kubie, "The IBM magnetic drum calculator type 650," Association for Computing Machinery, Cambridge, Massachusetts, September 10, 1953.

Small commercial electronic computers were used more and more for business computation. The 409-2 computer contains an electronic arithmetic element that includes a 22-column parallel accumulator employing biquinary decade counters. The total electron-tube complement includes 1467 vacuum tubes and 1128 cold-cathode gas diodes. Most of these are designed and manufactured especially for computer use. The acceptance of the type 604 electronic calculator, over 1000 of which are now in use led to the development of a similar machine, the type 607, having increased program and storage capacity. A maximum of 140 program steps is provided with a period of 520 microseconds per step.

(716) L. P. Crosman, "The Remington Rand type 409-2 electronic computer," PROC. I.R.E., vol. 41, pp. 1332–1340; October, 1953.

Noncommercial large-scale electronic computers, many of them designed and operated in university and government laboratories and nearly all of them sponsored by the Federal Government, continued to play an important role. Their development not only contributed to the fields of logical design, components, and techniques, systems development and operation, and programming, but continued to provide urgently needed computing facilities. Two machines patterned after the SEAC appeared, FLAC and MIDAC. FLAC was built for computing flight characteristics of guided missiles. A serial binary machine with a one-megacycle pulse rate and floating three-address code, FLAC is notable for its compactness, utilizing only 800 tubes and dissipating less than 7.5 kilowatts. MIDAC has a magnetic-drum low-speed memory to supplement the high-speed acoustic storage. Another computer, the Oracle, was completed. The first paper describing it, at the Institute for Advanced Study, which had profound influence on the entire computer field, is listed, together with several selected references describing noncommercial machines.

(717) G. Estrin, "The electronic computer at the Institute for Advanced Study," *Mathematical Tables and other Aids to Computation*, vol. 7, pp. 108–114; April, 1953.

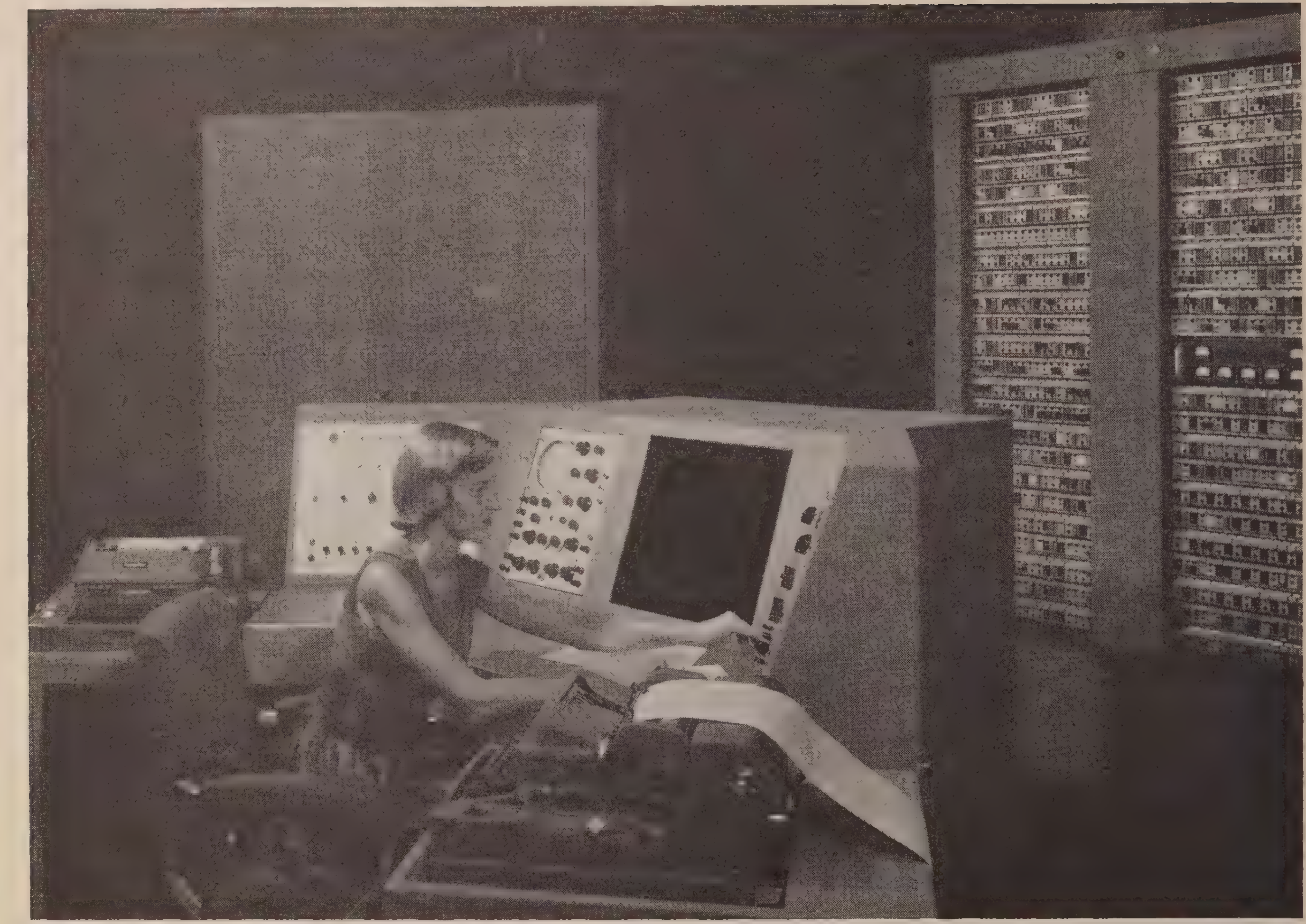
(718) P. C. Scherertz, "Electronic circuits of the NAREC computer," PROC. I.R.E., vol. 41, pp. 1313–1320; October, 1953.

(719) S. Greenwald, R. C. Haueter, and S. N. Alexander, "SEAC," PROC. I.R.E., vol. 41, pp. 1300–1313; October, 1953.

(720) H. D. Huskey, R. Thorensen, B. F. Ambrosio, and E. C. Yowell, "The SWAC-design features and operating experience," PROC. I.R.E., vol. 41, pp. 1294–1299; October, 1953.

(721) S. E. Gluck, "The electronic discrete varible computer," *Elec. Eng.*, vol. 72, pp. 159–162; February, 1953.

The Logistics Computer, a special-purpose, fixed-sequence electronic computer designed for the Office of Naval Research by Engineering Research Associates Division of Remington Rand, Inc. The computer is being used for research covering logistics data-processing methods at the George Washington University, Logistics Record Project.



The FLAC computer, used in computing flight characteristics of guided missiles flown over a test range, at the Air Force Missile Test Center in Florida.

The successful application of computers and information-processing systems to business and control problems marked the beginning of an important technology. The ERA manufacturer produced a special-purpose magnetic-drum system for use as an aid in the control of aircraft movements and in the collection and dissemination of weather information. Another ERA system is an office-type machine called Speed-Tally, which is used to maintain up-to-the-minute record of the orders received for each of some 12,000 catalog items at a mail-order concern. A large-scale laboratory model of an automatic telephone switching office employing a magnetic-drum memory was constructed and operated successfully. A general-purpose digital computer with specialized input-output equipment was developed for use in airborne control systems.

(722) W. A. Malthaner and H. E. Vaughan, "An automatic telephone system employing magnetic drum memory," Proc. I.R.E., vol. 41, pp. 1341–1347; October, 1953.
(723) E. C. Nelson, "A digital computer for airborne control systems," *The Transactions of the I.R.E. Professional Group on Electronic Computers*, vol. PGEC-1, pp. 2–5; December, 1952.
(724) J. R. Shull, "An automatic cruise control computer for long range aircraft," *The Transactions of the I.R.E. Professional Group on Electronic Computers*, vol. PGEC-1, pp. 47–51; December, 1952.
(725) H. L. Foote, "The XY toll ticketing system," *Elec. Eng.*, vol. 72, pp. 517–522; June, 1953.
(726) R. S. Erickson, "The logistics computer," Proc. I.R.E., vol. 41, pp. 1325–1332; October, 1953.
(727) J. J. Stone, "The USAF-Fairchild specialized digital computer," *Mathematical Tables and other Aids to Computation*, vol. 7, pp. 35–37; January, 1953.
(728) J. P. Walker, Jr., "A special purpose digital computer," *Mathematical Tables and other Aids to Computation*, vol. 7, pp. 190–195; July, 1953.

The first of a new line of analog computers featured the ability to provide custom computer installations with standard computing components by making most components plug-in and interchangeable.

(729) M. V. Wilkes, "Can machines think?," Proc. I.R.E., vol. 41, pp. 1230–1234; October, 1953.
(730) C. E. Shannon, "Computers and automata," Proc. I.R.E., vol. 41, pp. 1234–1241; October, 1953.
(731) W. H. Thomas, "Fundamentals of digital computer programming," Proc. I.R.E., vol. 41, pp. 1245–1249; October, 1953.
(732) G. M. Hopper and J. W. Mauchly, "Influence of programming techniques on the design of computers," Proc. I.R.E., vol. 41, pp. 1250–1254; October, 1953.
(733) N. Rochester, "Symbolic programming," *The Transactions of the I.R.E. Professional Group on Electronic Computers*, vol. EC-2, pp. 10–15; March, 1953.
(734) R. Serrell, "Elements of Boolean algebra for the study of information-handling systems," Proc. I.R.E., vol. 41, pp. 1366–1380; October, 1953.
(735) D. J. Wheeler and J. E. Robertson, "Diagnostic programs for the Illiac," Proc. I.R.E., vol. 41, pp. 1320–1325; October, 1953.
(736) A. W. Burks and J. B. Wright, "Theory of logical nets," Proc. I.R.E., vol. 41, pp. 1357–1365; October, 1953.

(737) G. S. White, "Coded decimal number systems for digital computers," Proc. I.R.E., vol. 41, pp. 1450–1542; October, 1953.
(738) R. E. Spero, "Effectiveness of two-step smoothing in digital control computers," Proc. I.R.E., vol. 41, pp. 1465–1469; October, 1953.
(739) W. D. Lewis, "Electronic computers and telephone switching," Proc. I.R.E., vol. 41, pp. 1242–1244; October, 1953.
(740) N. H. Taylor, "Rudiments of good circuit design," *Proceedings of the 1953 Electronic Components Symposium*, Pasadena, California, April 29–30, May 1, 1953.
(741) M. Rubinoff, "Analogue vs. digital computers—a comparison," Proc. I.R.E., vol. 41, pp. 1254–1262; October, 1953.
(742) G. A. Korn and T. M. Korn, "Electronic Analog Computers," McGraw-Hill Book Co., New York, N. Y., 1952.
(743) L. G. Walters, "Hidden regenerative loops in electronic analog computers," *The Transactions of the I.R.E. Professional Group on Electronic Computers*, vol. EC-2, p. 1–4; June, 1953.
(744) C. A. Meneley and C. D. Morrill, "Application of electronic differential analyzers to engineering problems," Proc. I.R.E., vol. 41, pp. 1487–1496; October, 1953.
(745) R. R. Bennett, "Analog computing applied to noise studies," Proc. I.R.E., vol. 41, pp. 1509–1513; October, 1953.

The Speed-Tally system, electronic tallying and inventory record-keeping equipment developed by Engineering Research Associates Division of Remington Rand, Inc. Ten keyboard stations permit 75,000 entries per day into a magnetic drum storage holding 39,000 item records.

Components and Techniques

Component reliability, of primary importance in large electronic computers, received increased attention. Tubes were manufactured specifically for computer service and better high-quality receiving tubes for application in large systems were developed. The reliability of the transistor as a possible substitute for the electron tube was studied. Other components also received attention.

(746) "Proceedings of the 1953 Electronic Component Symposium," Pasadena, Calif.; April 29–May 1, 1953.
(746-A) T. D. Hinkleman, "The UNIVAC tube program," *The Transactions of the I.R.E. Professional Group on Electronic Computers*, vol. EC-2, pp. 8–12; September, 1953.

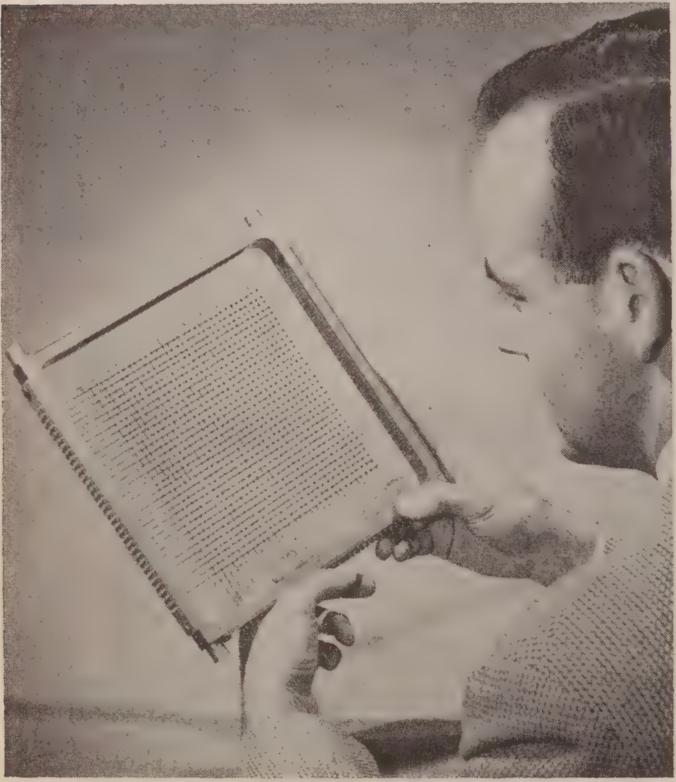
An important technical development was the successful application of a high-speed memory system employing magnetic cores. This technique, employing ferrite cores with rectangular hysteresis loops, permits very short access times with a high degree of reliability. The electrostatic storage of the Whirlwind I computer was replaced with 2048 registers of magnetic-core storage to produce a 50-per cent increase in operating speed. An experimental 10,000-binary-digit magnetic-core memory was demonstrated. A high-speed static magnetic memory was used in connection with the operation of ENIAC. Storage of information is accomplished by 4100 magnetic cores made of one of the rectangular-hysteresis-loop ferromagnetic materials. Information can be stored or extracted in less than 25 microseconds. A number of magnetic-core memories were under design at various computer laboratories.

(747) J. A. Rajchman, "A myriabit magnetic-core matrix memory," Proc. I.R.E., vol. 41, pp. 1407–1421; October, 1953.
(748) D. R. Brown and E. Albers-Schoenberg, "Ferrites speed digital computers," *Electronics*, vol. 26, pp. 146–149; April, 1953.
(749) M. K. Haynes, "Multidimensional magnetic memory selection systems," *The Transactions of the I.R.E. Professional Group on Electronic Computers*, vol. PGEC-1, pp. 25–32; Dec., 1952.

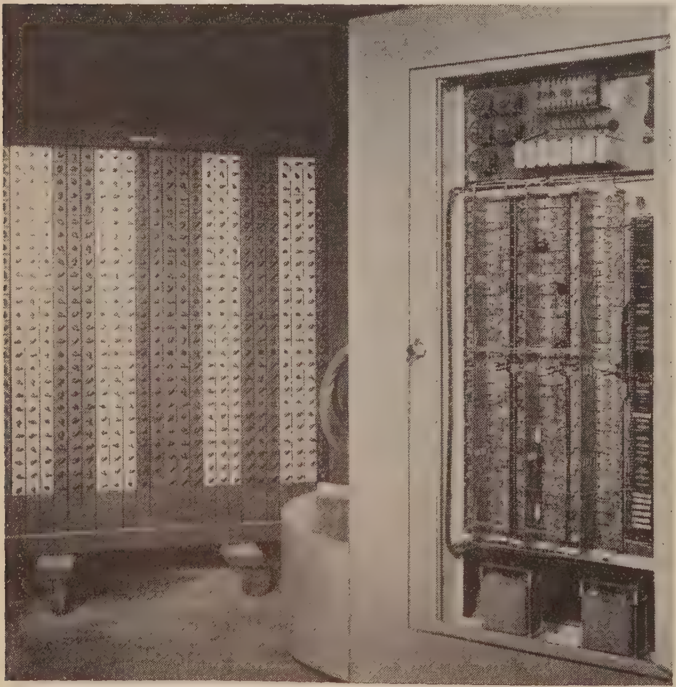
An improved technique for the use of Williams type electrostatic storage was announced, and a survey article appeared.

(750) R. Thorensen, "An improved cathode ray tube storage system," Western Computer Conference, Los Angeles, California, February 6, 1953.
(751) J. P. Eckerts, Jr., "A survey of digital computer memory systems," Proc. I.R.E., vol. 41, pp. 1393–1406; October, 1953.
(752) G. W. King, G. W. Brown, and L. N. Ridenour, "Photographic techniques for information storage," Proc. I.R.E., vol. 41, pp. 1421–1428; October, 1953.
(753) J. H. McGuigan, "Combined reading and writing on a magnetic drum," Proc. I.R.E., vol. 41, pp. 1438–1444; Oct., 1953.

(754) J. T. Potter and P. C. Michel, "High density digital recording system," *The Transactions of the I.R.E. Professional Group on Electronic Computers*, vol. PGEC-1. pp. 60–72; December, 1952.



A 1,024-bit magnetic-core memory plane used in the high-speed magnetic-storage system recently installed in the Whirlwind I Computer at the Massachusetts Institute of Technology.



The new high-speed static magnetic memory, designed and constructed by the Philadelphia Research Center of Burroughs Corp., connected to ENIAC at the Ballistics Research Laboratory, Aberdeen Proving Ground, Md. This unit has a storage capacity of 4,100 bits and an access time of 25 microseconds.

The use of ferromagnetic techniques to replace vacuum tubes in computer control, arithmetic, and storage sections was announced. These devices are called magnetic decision elements, and operate to perform the logical functions; "and," "negation," "exclusive-or," "inclusive-or," and so forth. Each decision element is a one-inch cube that weighs one ounce, consumes less than 0.5 watt, contains only solid-state components, and performs the functions of decision (switching, gating, mixing, etc.), storage, power gain, and pulse shaping. No linkages other than the wire connections are required between elements. Present standard rate of information travel is 100 kc from a two-phase, 200-kc synchronizing clock source.

(755) J. D. Goodell, "The foundations of computing machinery," *The Journal of Computing Systems*, vol. 1, pp. 86–110; January, 1953.

A discussion of input-output equipment including the input-output systems of the SEAC, UNIVAC, RAYDAC, and 701 may be found in the "Review of Input and Output Equipment Used in Computing Systems" sponsored by the Joint AIEE-IRE-ACM Computer Conference Committee held December 10–12, 1952, and published in March, 1953. With the application of electronic digital computers to problems of automatic control, a number of techniques for analog-to-digital conversion appeared. Many of these were developed for airborne systems. The following papers, in addition to those that may be found in the above reference, deal with input-output equipment.

(756) H. E. Burke, Jr., "A survey of analog-to-digital converters," Proc. I.R.E., vol. 41, pp. 1455–1462; October, 1953.
(757) H. J. Gray, Jr., P. V. Levonian, and M. Rubinoff, "An analog-to-digital converter for serial computing machines," Proc. I.R.E., vol. 41, pp. 1462–1465; October, 1953.
(758) W. H. Libaw and L. J. Craig, "A photoelectric decimal-coded shaft digitizer," *The Transactions of the I.R.E. Professional Group on Electronic Computers*, vol. EC-2, pp. 1–4; September, 1953.
(759) A. D. Scarbrough, "An analog-to-digital converter," *The Transactions of the I.R.E. Professional Group on Electronic Computers*, vol. EC-2, pp. 5–7; September, 1953.
(760) B. G Welby, "Intermittent-fed computer-tape reader," *Electronics*, vol. 26, pp. 115–117; February, 1953.
(761) P. R. Vance and D. L. Haas, "An input-output unit for analog computers," Proc. I.R.E., vol. 41, pp. 1483–1486; October, 1953.

A number of improved techniques were described including dynamic circuit techniques used in the SEAC and the newer DYSEAC.

(762) R. D. Elbourn and R. P. Witt, "Dynamic circuit techniques used in SEAC and DYSEAC," Proc. I.R.E., vol. 41, pp. 1380–1387; October, 1953.
(763) S. E. Gluck, H. J. Gray, Jr., C. T. Leondes, and M. Rubinoff, "The design of logical OR-AND-OR pyramids for digital computers," Proc. I.R.E., vol. 41, pp. 1388–1392; October, 1953.
(764) C. E. Shannon and E. F. Moore, "Machine aid for switching circuit design," Proc. I.R.E., vol. 41, pp. 1348–1351; October, 1953.
(765) W. H. Ware, "The logical principles of a new kind of binary counter," Proc. I.R.E., vol. 41, pp. 1429–1437; October, 1953.
(766) E. L. Kemp, "Gated decade counter requires no feedback," *Electronics*, vol. 26, pp. 145–147; February, 1953.
(767) R. Pressman, "How to design bistable multivibrators," *Electronics*, vol. 26, pp. 164–168; April, 1953.
(768) C. L. Wanlass, "Static-dynamic design of flip-flop circuits," *The Transactions of the I.R.E. Professional Group on Electronic Computers*, vol. PBEC-1, 6–18; December, 1952.

(769) J. O. Paivinen and I. L. Auerbach, "Design of triode flip-flop for long-term stability," *The Transactions of the I.R.E. Professional Group on Electronic Computers*, vol. EC-2, pp. 14–26; June, 1953.
(770) J. H. Vogelsong, "A transistor pulse amplifier using external regeneration," Proc. I.R.E., vol. 41, pp. 1444–1450; October, 1953.
(771) J. R. Anderson, "Electrical delay lines for digital computer applications," *The Transactions of the I.R.E. Professional Group on Electronic Computers*, vol. EC-2, pp. 5–13; June, 1953.
(772) C. D. Morrill and R. V. Baum, "A stabilized electronic multiplier," *The Transactions of the I.R.E. Professional Group on Electronic Computers*, vol. PGEC-1, pp. 52–59; December, 1952.
(773) W. A. McCool, "An AM-FM electronic analog multiplier," Proc. I.R.E., vol. 41, pp. 1470–1477; October, 1953.
(774) L. J. Craig, "The magnetic amplifier as an analog computer component," Proc. I.R.E., vol. 41, pp. 1477–1482; October, 1953.

Quality Control

Manufacturers, particularly in the electronics field, showed an increased interest in the application of statistical methods to the control of product quality. Attention was directed also to the equipment for making the tests on which the control is based.

(775) R. D. Guild, "Statistical appraisal of vacuum tube reliability." Presented at Annual Convention, American Society for Quality Control, Philadelphia, Pa.; May 28–30, 1953.
(776) G. R. Herd, "Application of statistical methods in evaluating performance of electronic equipment," *Quality Control Conference Papers 1953*, Amer. Soc. Quality Control.
(777) J. A. Davies, "How reliable is your life test equipment?" *Quality Control Conference Papers 1953*, Amer. Soc. Quality Control.
(778) B. Epstein, "Statistical problems in life testing," *Quality Control Conference Papers 1953*, Amer. Soc. Quality Control.

Ordinary statistical techniques cannot handle all kinds of quality-control problems. However, the scope of the quality-control function can be increased by using electronic devices.

(779) D. M. Longenecker, "Integrating instruments for simplified quality control measurements," *Commun. and Electronics*, no. 8, pp. 375–380; September, 1953.
(780) W. H. MacWilliams, Jr., "Computers—past, present, and future," *Elec. Eng.*, vol. 72, no. 2, pp. 116–121; February, 1953.
(781) C. R. Strong, "Computing machines in aircraft manufacturing," *Elec. Eng.*, vol. 72, no. 1, pp. 43–48; January, 1953.

Radio Telemetering and Remote Control

The FM/FM with or without PAM continued to make strides in the field of industrial telemetering as well as for airborne installations. Systems providing several hundred channels within the accepted 18-band standard were constructed.

A PCM telemeter was developed. Although not as light or as small as an FM/FM PAM system, it provides greater accuracy, especially under conditions of high noise levels.

Commercial crystal-controlled transmitters in the 200-mc telemetering band are phase modulated. This reverses the problems of pre-emphasis as compared to an FM transmitter, the low frequencies being hardest to transmit with very low distortion and adequate modulation sweep.

Primary recording on magnetic tape continued in favor, the data reduction using filters and discriminators being done during playback. A unique technique allows a magnetic recording to be provided with a grid calibrated in function units.

The first completely integrated installation for reduction of all types of films, dial indications, telemetering records, and manually operated keyboard data provides either IBM punch-card signals, tabulated typewritten data or data plots.

The trend towards all-dc pickups for measuring pressure and acceleration as well as position and displacement continued.

Voltage-controlled subcarrier oscillators can provide high accuracy if a calibrating voltage is commutated with the pickup outputs.

Miniature tubes replaced subminiatures in certain airborne units with no increase in the over-all package dimensions.

New applications for radio telemetering included the measurement of grain height, aero-medical studies, and low-frequency drilling for oil. The recent decision of the FCC to allow remote operation of radio stations if the control center is equipped with continuous recordings of certain transmitter functions provided a large new field for which FM/FM telemetering is especially suited.

Magnetics

Ferromagnetic nonmetals, or ferrites, continues to play a large role in the field of magnetics. They combine the magnetic properties of metals, electric and dielectric properties of semiconductors, and physical properties of ceramics. While the varieties of ferrites were extended and their properties improved, a certain degree of standardization was achieved. Ferrite-type permanent magnets were developed and made available commercially.

(782) A. Fairweather, F. F. Roberts, and A. J. E. Welch, "Ferrites," *Rep. Progr. Phys.* (London), vol. 15, pp. 142–172; 1952.
(783) R. Feldtkeller and O. Kolb, "Complex permeability of a highly permeable ferrite core," (In German), *Z. Angew. Phys.*, vol. 4, pp. 448–451; December, 1952.
(784) J. P. Allen, "A microwave magnetometer," Proc. I.R.E., vol. 41, pp. 100–104; January, 1953.
(785) F. Reggia and R. W. Beatty, "Characteristics of the magnetic attenuator," Proc. I.R.E., vol. 41, pp. 93–100; January, 1953.
(786) N. G. Sakiotis and H. N. Chait, "Ferrites at microwaves," Proc. I.R.E., vol. 41, pp. 87–93; January, 1953.
(787) C. D. Owens, "Analysis of measurements on magnetic ferrites," Proc. I.R.E., vol. 41, pp. 359–365; March, 1953.
(788) H. A. Stone, Jr., "Ferrite core inductors," *Bell Sys. Tech. Jour.*, vol. 32, pp. 265–291; March, 1953.
(789) C. M. van der Burgt, M. Gevers, and H. P. J. Wijn, "Measuring methods for some properties of Ferroxcube materials," *Philips Tech. Rev.*, vol. 14, pp. 245–256; March, 1953.
(790) W. van B. Roberts, "Some applications of permanently magnetized Ferrite resonators," *RCA Rev.*, vol. 14, pp. 3–16; March, 1953.
(791) D. R. Brown and E. Albers-Shoenberg, "Ferrites speed digital computers," *Electronics*, vol. 26, pp. 146–149; April, 1953.
(792) C. M. van der Burgt, "Dynamical parameters in the magnetostrictive excitation of extensional and torsional vibrations in ferrites," *Philips Res. Rep.*, vol. 8, pp. 91–132; April, 1953.

Several committees were concerned with standardizing measuring methods and relating intrinsic properties of magnetic materials with core characteristics and performance. A new radio-frequency permeameter was developed for measuring the permeability and Q of toroidal cores without windings. Temperature coefficients and aging characteristics of magnetic powder cores were subject to further study.

(793) P. H. Haas, "A Radio Frequency Permeameter," *NBS Report 2071;* November 20, 1952.
(794) D. F. W. Champion and G. E. Wilkins, "Magnetic powder cores," *Wireless World*, vol. 59, pp. 83–86; February, 1953.
(795) W. J. Polydoroff, "Powdered magnetic cores," *Tele-Tech.*, vol. 12, pp. 69–71, 112+; February, 1953.
(796) E. J. Oelbermann, R. E. Shipper, and W. J. Leiss, "Moisture-aging of powder-core toroids," *Electronics*, vol. 26, pp. 236, 238, 240; May, 1953.
(797) S. R. Hoh, "Evaluation of high performance magnetic core materials," *Tele-Tech.*, vol. 12, pp. 86–89+, October, 1953; pp. 92–94+, November, 1953.

Much work was directed to the difficult problem of relating the nonlinear characteristics of magnetic cores to the design requirements and performance specifications of magnetic amplifiers. As better magnetic materials, more efficient rectifiers and improved circuits emerge, magnetic amplifiers are finding ever-wider applications.

(798) D. C. Dieterly, "Evaluation of core materials for magnetic amplifiers," *Elec. Mfg.*, vol. 51, pp. 124–127, 380; February, 1953.
(799) G. M. Ettinger, "Butterfly curve tracer for magnetic materials," *Electronics*, vol. 26, pp. 119–121; March, 1953.
(800) H. W. Lord, "Dynamic hysteresis loops of several core materials employed in magnetic amplifiers," *Comm. and Electronics*, No. 5, pp. 85–88; March, 1953.
(801) R. W. Roberts, "Magnetic amplifiers," *Mach. Design*, vol. 25, pp. 171–179; April, 1953.
(802) G. F. Schroeder, "What magnetic amplifiers can do to increase aircraft reliability," *Aero. Eng. Rev.*, vol. 12, pp. 92–95; May, 1953.
(803) W. C. Johnson, "Magnetic amplifier," *Elec. Eng.*, vol. 72, pp. 583–588; July, 1953.
(804) L. A. Finzi and G. F. Pittman, Jr., "Methods of magnetic amplifier analysis," *Elec. Eng.*, vol. 72, pp. 690–694; August, 1953.
(805) S. R. Hoh, "Magnetic Amplifiers," *Tele-Tech*, vol. 12, pp. 68–70, 135+; May, 1953.
(806) R. A. Ramey, "Magnetic amplifier circuits and applications," *Elec. Eng.*, vol. 72, pp. 791–795; September, 1953.

The entire issue of *Reviews of Modern Physics*, vol. 25, January, 1953, was devoted to the papers and discussions of the Washington conference on magnetism held in September, 1952. These papers broadly survey the fields of theoretical and experimental magnetism. Several sessions on magnetism were included in the International Conference on Theoretical Physics held in Japan in September, 1953. A number of general reviews of theoretical and applied magnetism appeared.

(807) W. Dannöhl, "Development and present state of materials for permanent magnets," (In German), *Stahl U. Eiseu*, vol. 73, pp. 65–81; January 15, 1953.
(808) R. M. Bozorth, "Behavior of magnetic materials," *Amer. Jour. Phys.*, vol. 21, pp. 260–266; April, 1953.
(809) R. E. Alley, Jr., "A review of new magnetic phenomena," *Bell Sys. Tech. Jour.*, vol. 32, pp. 1155–1172; September, 1953.

Instrumentation and Measurements

Basic Standards and Calibration Methods: The International Scientific Radio Union (URSI) recommended that 299,792±2 km/sec be adopted as the velocity of electromagnetic waves in vacuum. A standard was published on methods of measuring noise. Methods of measuring the constants of piezoelectric vibrators were reviewed.

A report on standard frequency transmissions and time signals was adopted by the International Radio Consultative Committee (CCIR). WWV in Washington broadcast continuously in all allocated standard-frequency bands. Experimental transmissions in some of these bands were continued by WWVH, Hawaii; MSF, Rugby; IBF, Torino; and JJY, Tokyo. An experimental broadcast was commenced by ZRE21, Johannesburgh.

Quartz-crystal clocks of improved constancy and uniformity provided frequencies accurate to within 1 part in 10.

(810) D. A. Alsberg, "Principles and applications of converters for high-frequency measurements," Proc. I.R.E., vol. 40, pp. 1195–1203; October, 1952.
(811) P. M. Ratcliffe, "The design of microwave-noise generators," *Marconi Instrumentation*, vol. 3, pp. 124–127; October, 1952.
(812) H. Voigt, "A measurement bridge for 0.1–1000 Mc/s," *Arch. elekt. Übertragung*, vol. 6, pp. 414–418; October, 1952.
(813) J. P. Griffin, "High-stability 100-kc crystal units for frequency standards," *Bell Lab. Rec.*, vol. 30, pp. 433–437; November, 1952.
(814) L. Hartshorn, "Units and standards of electrical measurement —A review of progress," *Proc. IEE (London) Part 1*, vol. 99, pp. 271–279; November, 1952.
(815) International Scientific Radio Union (URSI), Proc. General Assembly Commission I, Measurement Methods and Standards, vol. 9, 1952.
(816) H. R. Meahl and C. C. Allen, "Calibrating ammeters above 100 Mc," Proc. I.R.E., vol. 41, pp. 152–159; January, 1953.
(817) "Improvements in the N.B.S. primary standard of frequency," *Tech. News Bulletin*, National Bureau of Standards, vol. 37, pp. 8–12; January, 1953.
(818) J. J. Freeman, "Noise comparator for microwaves," *Radio & Television News*, Radio-Electronics Eng. Sec., vol. 49, pp. 11, 49; March, 1953.
(819) L. J. Rueger and A. E. Wilson, "The microwave frequency standard," *Radio & Television News*, Radio-Electronic Eng. Sec., vol. 49, pp. 5–7, 41; March, 1953.
(820) "Standards on electron devices: methods of measuring noise," Proc. I.R.E., vol. 41, pp. 890–896; July, 1953.
(821) R. W. Beatty and A. C. Macpherson, "Mismatch errors in microwave power measurements," Proc. I.R.E., vol. 41, pp. 1112–1119; September, 1953.
(822) E. A. Gerber, "A review of methods for measuring the constants of piezoelectric vibrators," Proc. I.R.E, vol. 41, pp. 1103–1112; September, 1953.
(823) H. J. Finden, "Developments in frequency synthesis," *Elec. Eng.*, vol. 25, pp. 178–183; May, 1953.

Oscillography: A counter-type chronograph was developed for ballistics measurements. A cathode-ray tube indicated timing signals reducing the confusion that might result from random-noise signals. A 10-line time scale was displayed on a 10-line raster by means of clipped pulses. Sweep generators were controlled by a tuning fork. The maximum measured time was 10^5 microseconds.

(824) H. Moss, "Recurrent-sweep cronograph," *Electronic Eng.* (London), vol. 25, pp. 282–286; July, 1953.

A system was developed for displaying antenna-radiation patterns on a cathode-ray tube. An antenna was supported on a slowly rotating platform for investigation. The local test transmitter served to excite the antenna so that the resulting signal voltage was proportional to the power of the received signal. During rotation of the turn table, a luminous area was swept out across the screen. Suitable blanking arrangements permitted the contour to be displayed.

(825) T. T. Ling, "Aerial radiation patterns," *Wireless Eng.*, vol. 30, pp. 192–195; August, 1953.

A double-beam wide-band oscillograph for measuring atmospheric or other noise was described. One channel was designed for 10-mc response and the other channel covered a bandwidth of 0.1 to 250 mc. High-voltage intensification was provided for making photographic records.

(826) M. M. Newman, R. C. Schwantes, and J. R. Stahmann, "Aircraft radio-interference measurements," *Elec. Eng.*, N. Y., vol. 72, pp. 36–40; January, 1953.

A system was described for automatic operation of a cathode-ray oscillograph to display groups of characteristics of point-contact and junction transistors.

(827) J. Kurshaw, R. D. Lohman, and G. B. Herzog, "Cathode-ray tube plots transistor curves," *Electronics*, vol. 26, pp. 122–127; February, 1953.

A system was developed for analyzing signal distortion by means of a network that removed the fundamental portion so that the distorted components could be passed through a suitable amplifier. The resulting signal was applied to a cathode-ray oscillograph and the difference diagram was compared with reference patterns to determine the sources of distortion.

(828) E. R. Wigan, "Diagnosis of distortion. 'Difference diagram' and its interpretation," *Wireless World*, vol. 59, pp. 261–266; June, 1953.

High Frequency Measurements: A book including sections on instruments for high-frequency measurements was published. A conference on high-frequency measurements was held in Washington, and papers presented are referred to under the applicable type of measurement.

(829) R. P. Turner, "Basic Electronic Test Instruments," Reinhart Books, Inc., New York, N. Y.; 1953.
(830) "I.R.E./A.I.E.E. meeting on high-frequency measurements," Proc. I.R.E., vol. 41, pp. 172–173; January, 1953.
(831) Reich, Ordung, Krauss, and Skalnik, "Microwave Theory and Techniques," D. Van Nostrand Company, New York, N. Y.; 1953.

Two review articles surveyed the known techniques of measurement in the more-specialized fields of piezoelectric vibrators and high-frequency ammeters.

(832) E. A. Gerber, "A review of methods for measuring the constants of piezoelectric vibrators," Proc. I.R.E., vol. 41, pp. 1103–1112; September, 1953.
(833) H. R. Meahl and C. C. Allen, "Calibrating ammeters above 100 mc," Proc. I.R.E., vol. 41, pp. 152–159; January, 1953.

The Faraday rotation of microwaves was used in the accurate determination of magnetic-field intensity, since the angle of rotation of the polarization is linearly related to the applied magnetic field.

(834) P. J. Allen, "A microwave magnetometer," Proc. I.R.E., vol. 41, pp. 100–104; January, 1953.

An instrument that compares the amplitude of a narrow-band signal with a wide-band noise power (not including the signal frequency) from the same channel permits and allows for rapid measurements of signal-to-noise ratio in television links.

(835) R. Moffett, "Signal-noise meter checks TV links," *Electronics*, vol. 26, pp. 164–165; October, 1953.

Frequency and Time: Improvements in the primary standards of frequency at the National Bureau of Standards were reported. The new oscillators operate at an extremely low current to increase stability. The standard crystals are temperature controlled within ±0.001 degree centigrade and are used as resonators. The possibility of locating crystal resonators underground to obtain extremely uniform ambient temperature is being studied.

(836) "Improvements in the N.B.S. primary standard of frequency," *Tech. Bull. Nat. Bur. Stand.*, vol. 37, pp. 8–12; January, 1953. (Abstract 1731)
(837) T. A. Pendleton, "Performance and reliability considerations of underground quartz-crystal resonators." Presented at the Conference on High Frequency Measurements; January, 1953.

A small self-contained secondary frequency standard of 100 kc uses a transistor oscillator operating from a long-life mercury cell. A crystal resonator as much as 1,000 times more precise than those now commercially available was described. It uses an AT-cut crystal plate, operated in the optimum overtone. To increase the Q further, the crystal is given a spherical curvature to restrict vibration to the center of the plate and eliminate energy loss to the mount. A frequency standard was described in which interpolation between harmonics of a crystal calibrator was obtained by measuring the heterodyne frequency difference between harmonics of the calibrator and the unknown frequency on an accurately calibrated communications receiver. Accuracies within about 1 part in a million are claimed.

(838) "Precision transistor oscillator," *Tech. Bull. Nat. Bur. Stand.*, vol. 37, pp. 17–19; February, 1953. (Abstract 2064)
(839) A. W. Warner, "Precise high-frequency crystal units," *Bell Lab. Rec.*, vol. 31, pp. 205–210; June, 1953.
(840) L. C. Hedrick, "Microwave frequency standard," *Rev. Sci. Instr.*, vol. 24, pp. 565–568; August, 1953.

The first book devoted exclusively to microwave spectroscopy was published.

(841) W. Gordy, W. V. Smith, and R. F. Trambarulo, "Microwave Spectroscopy," John Wiley and Sons, New York, N. Y., 1953.

For measurements in the uhf television band, a grid-dip meter operating from 390 to 1,000 mc was developed.

(842) A. E. Hylas and W. V. Tyminski, "UHF grid-dip meter," *Electronics*, vol. 26, pp. 175–177; April, 1953. (Abstract 2080)

Quasioptical methods are becoming more widely used for microwaves. In one case, millimeter wavelengths were measured with spectrometers and interferometers. In two other cases microwave analogs of the Fabry-Perot interferometer (the cylindrical cavity) and the Michelson interferometer (the hybrid-T junction) were used to measure the wavelength of an accurately known frequency, from which the velocity of electromagnetic waves was calculated. Values of 299,792.5 km/sec and 299,789.4 km/sec were measured by this method as contrasted with 299,776 km/sec, the usually accepted value for the velocity of light.

(843) J. R. Martin and C. F. Schunemann, "Measuring wavelength in millimeters," *Electronics*, vol. 26, pp. 184–187; May, 1953. (Abstract 2386)
(844) L. Essen, "Precision measurements of the velocity of electromagnetic waves and the refractive indices of gases at microwave frequencies." Presented at the Conference on High-Frequency Measurements; January, 1953.
(845) W. W. Hansen, W. J. Barclay, and K. Bol, "Precision microwave measurement of propagation velocity of electromagnetic waves." Presented at the Conference on High Frequency Measurements; January, 1953.

Impedance Measurements at High Frequencies: Two instruments were described for plotting impedance or mismatch measurements. One plots impedance, for frequencies from 100 to 400 mc, directly on a Smith chart overlay applied to an oscilloscope tube face. The other plots VSWR against frequency over two ranges covering all frequencies between 100 and 1300 mc. Both are extremely useful for broad-band work as the variation of these values with frequency can be observed while modifications are being made to the unknown.

(846) K. S. Packard, "Automatic Smith-chart plotter," *Tele-Tech.*, 12, pp. 65–67, 183; April, 1953. (Abstract 3065)
(847) W. P. Peyser, "Swept wide-range SWR indicators for 100 through 1350 megacycles." Presented at the Conference on High Frequency Measurements; January, 1953.

Interest in the low losses in circular waveguides using the TE_{01} mode stimulated development of special methods of impedance measurements.

Geometric relations of the reflection coefficient measured at the input of a waveguide junction when a short-circuit is moved beyond the junction were applied to the determination of reflection coefficient and insertion loss of the waveguide junction. Measurement of phase difference between two points close to but equidistant from the minimum in a standing-wave pattern were used to measure VSWR too high to be measured accurately by other methods.

(848) L. S. Sheingold, "Impedance measurements in a circular waveguide with TE_{01} excitation," Proc. I.R.E., vol. 41, p. 423; March 1953. Summary of I.R.E. convention paper.
(849) G. A. Deschamps, "Determination of reflection coefficients and insertion loss of a waveguide junction," *Jour. Appl. Phys.*, vol. 24, pp. 1046–1050; August, 1953.
(850) T. J. Buchanan, "The measurement of high standing-wave ratios," *Proc. IEE* (*London*), part 4, vol. 99, pp. 372–375; December, 1952.

Three new impedance bridges were described. The first is for operation in the 10–100 mc range and the second covers 0.5 to 250 mc. The first measures low-inductance values directly with a readability of 0.0001 microhenry. The third, a new hybrid junction for microwaves, is different in that the symmetrical arms are adjacent and parallel to the *H*-arm, making a much-smaller and more-convenient device. Isolation between *E* and *H* arms of over 50 db was reported for a 12 per cent frequency bandwidth.

(851) J. E. Houldin and G. T. Thompson, "High-frequency bridge with variable ratio arms," *Wireless Eng.*, vol. 30, pp. 32–38; February, 1953. (Abstract 1433)
(852) J. H. Mennie, "A vhf impedance meter," Proc. I.R.E., vol. 41, p. 412; March, 1953. Summary of I.R.E. convention paper.
(853) M. D. Adcock, "Design, performance, and application of a new hybrid junction." Presented at the Conference on High-Frequency Measurements; January, 1953.

Power Measurements at High Frequency: High peak powers at microwave frequencies are difficult to measure reliably because duty cycle, average power, and pulse shape cannot be measured with sufficient precision to calculate peak power accurately. As a result, measurement of breakdown powers by different investigators seldom agree. An inexpensive and easily duplicated standard for comparison was proposed. It uses the calculable peak-power breakdown between two standardized hemispheres mounted on opposite sides of a standard waveguide as a repeatable standard of peak power.

(854) D. Dettinger, "A standard waveguide spark gap," Proc. I.R.E., vol. 40, p. 1604; November, 1952.

Measurement of microwave power by the torque exerted on a vane or magnetic dipole was reported. Accuracy within 1.5 per cent for pulsed powers between 10 and 60 watts was reported with one, and reasonable deflection on another with powers of 100 milliwatts or less.

A thermistor bridge for microwatt-power measurements used unique thermistor arrangement. Measuring and compensating thermistors are mounted at right angles in a single transverse plane in the waveguide. In this way, the bead temperatures are almost identical. Electromagnetic energy is coupled to one of the orthogonal thermistors, permitting the other to be effected by temperature alone. Errors in power measurement due to mismatch were reported in another article.

(855) A. L. Cullen and I. M. Stephenson, "A torque-operated wattmeter for 3-cm microwaves," *Proc. IEE* (*London*), part 4, vol. 99, pp. 294–301; December, 1952.
(856) A. L. Cullen, "A microwave vibration wattmeter," *Nature* (*London*), vol. 170, pp. 1121–1122; December 27, 1952.
(857) R. W. Lange, "40- to 4000-microwatt power meter," *Comm. and Electronics*, pp. 492–494; September, 1953.
(858) R. W. Beatty and A. C. Macpherson, "Mismatch errors in microwave power measurements," Proc. I.R.E., vol. 41, pp. 1112–1119; September, 1953.

In the field of detection, a testing procedure for measuring noise temperature and conversion loss of television mixer crystals was reported.

For microwave measurements requiring a heterodyne detector for sensitivity, linearity, or accuracy of IF attenuators, a method was described in which a part of the output of a source is phase-modulated to provide a signal while the remainder is used as a local oscillator.

(859) N. De-Wolf, "Testing U.H.F.-TV mixer crystals," *Electronics*, vol. 26, pp. 156–160; April, 1953.
(860) D. H. Ring, "A microwave double detection measuring system with a single oscillator." Presented at the Conference on High-Frequency Measurements; January, 1953.

Tunable terminations and broadband terminations for powers ranging from a few watts to 2 kilowatts were reported.

(861) R. C. Ellenwood and W. E. Ryan, "A uhf and microwave matching termination," Proc. I.R.E., vol. 41, pp. 104–107; January, 1953.
(862) T. N. Anderson, "High-powered microwave dummy loads," *Tele-Tech.*, vol. 12, pp. 92–94, 164; May, 1953. (Abstract 2892)

A new material of an animal-hair mat coated with carbon-filled neoprene absorbs over 98 per cent of the power at any frequency above 2000 mc, and is suitable for lining rooms used for antenna measurements.

A new type of attenuator, in which the calibration depends on only the angular relation of the component parts has become available. It is broadband and has an attenuation range from less than 1 db to over 50 db.

(863) A. J. Simmons and W. H. Emerson, "Anechoic chamber for microwaves," *Tele-Tech.*, vol. 12, pp. 47–49, 100–106; July, 1953.
(864) B. P. Hand, "A broad-band precision attenuator." Presented at the Conference on High Frequency Measurements; Jan., 1953.

Magnetically controlled attenuators and nonreciprocal devices using the Faraday effect were the primary objects of development in the field of microwaves. Nonreciprocal or unidirectional waveguide sections and magnetically controlled attenuators for the X-band are now commercially available.

(865) N. G. Sakiotis, "Ferrites at microwaves," PROC. I.R.E., vol. 41, pp. 87–93; January, 1953.
(866) F. Reggia and R. W. Beatty, "Characteristics of the magnetic attenuator at UHF," PROC. I.R.E., vol. 41, pp. 93–100; January, 1953.
(867) L. Goldstein, M. Gilden, and J. Etter, "Guided wave propagation through ferrites and electron gases in magnetic fields," PROC. I.R.E., vol. 41, pp. 426–427; March, 1953. Summary of I.R.E. convention paper.
(868) C. L. Hogan, "Ferromagnetic Faraday effect at microwave frequencies and its applications," *Rev. Mod. Phys.*, vol. 25, pp. 253–263; January, 1953.

Dielectric Constant: Two investigators reported on construction and measurement of artificial dielectrics. In one, the dielectric was constructed of small metallic obstacles printed on thin polystyrene sheets between spacers of polyfoam. In the other, metallic powder suspended in wax provided the dielectric medium.

A preference for measuring dielectrics by rectangular waveguide, short-circuited behind the sample, rather than by cavity methods was indicated. Methods vary with the form of the sample; whether solid, liquid or gas; the size of the sample required; and the type of test equipment needed.

(869) S. B. Cohn, "Microwave measurements on metallic delay media," PROC. I.R.E., vol. 41, pp. 1177–1183; September, 1953.
(870) J. M. Kelly, J. O. Stenoien, and D. E. Isbell, "Waveguide measurements in the microwave region on metal powders suspended in paraffin wax," *Jour. Appl. Phys.*, vol. 24, pp. 258–262; March, 1953. (Abstract 2328)
(871) A Surduts, "A method of measuring dielectric constant and complex permeability at ultra-high frequencies," *Compet. Rend. Acad. Sci.* (*Paris*), vol. 236, pp. 900–902; March 2, 1953. (Abstract 2383)
(872) J. LeBot and S. LeMontagner, "New method of measurement of the complex dielectric constant of solids and liquids at centimeter wavelengths," *Compt. Rend. Acad. Sci.* (*Paris*), vol. 236, pp. 469–471; February 2, 1953. (Abstract 2067)
(873) H. M. Altschuler and A. A. Oliner, "Precision measurements of dielectric constants and attenuation constants at microwave frequencies." Presented at the High-Frequency Measurements Conference; January, 1953.
(874) E. Hafner, "Determination of the dielectric constants of optically uniaxial crystals from the spectrum of natural oscillations of circular-cylinder cavity resonators," *Arch. Elek.* (*Uebertragung*), vol. 7, pp. 181–190; April, 1953.

Signal Sources: The major emphasis in the work on signal sources has been on oscillators capable of being swept in frequency over a wide band. Two mechanically swept *X*-band oscillators were described covering 8500 to 9500 mc. and 8000 to 10000 mc. respectively. Four references are listed reporting results on backward wave oscillators that can be electrically tuned. In the first it was reported that backward wave oscillators have been built at *X*-band, *K*-band and for frequencies up to 63 kmc. with power output of 10 milliwatts at 63 kmc. The second and third reported on a traveling-wave tube-type backward-wave oscillator using a slow-wave waveguide structure to obtain oscillations of 43 to 63 kmc, with a beam voltage variation from 600 to 2,300 volts. The last reported operation of a magnetron-type backward-wave oscillator producing powers of 200 watts with 30 per cent efficiency in the frequency range of 1624 to 2740 mc. Variation of frequency is obtained by varying the anode voltage between 4,000 and 6,000 volts.

(875) N. A. Spencer and D. Dettinger, "A waveguide cavity for an externally tuned reflex oscillator at 9 KMC." Presented at the Conference on High Frequency Measurements; January, 1953.
(876) I. D. Olin, "An X-band sweep oscillator," PROC. I.R.E., vol. 41, pp. 10–13; January, 1953.
(877) S. F. Kaisel, "Recent developments on a new type of wide range electronically tunable oscillator." Presented at the Conference on High Frequency Measurements; January, 1953.
(878) R. Kompfner, "Backward-wave oscillator," *Bell Lab. Rec.*, vol. 31, pp. 281–285; August, 1953.
(879) G. E. Helmke, "A hairpin tube backward-wave oscillator," *Bell Lab. Rec.*, vol. 31, pp. 286–291; August, 1953.
(880) E. C. Dench, " 'Carcinotron'—backward wave oscillator," *Tele-Tech.*, vol. 12, pp. 64–66, 157–165; November, 1953.

Interference Measurements: Plans for establishing a world-wide network of atmospheric noise recording stations have been made. Additionally, plans are underway to revise the world noise maps using recent subjective noise data measurements, establish a network of lightning stroke counters in collaboration with World Meteorological Organization, and to pursue co-ordinated studies of whistling atmospherics. The latter project may provide a new tool for ionospheric study.

Feedback Control Systems

New Books

(881) G. J. Thayler and R. G. Brown, "Servomechanism Analysis," McGraw-Hill Book Co., Inc., New York, N. Y., 414 pp.; 1953.
(882) F. E. Nixon, "Principles of Automatic Control," Prentice-Hall, Inc., New York, N. Y., 403 pp.; 1953.
(883) C. S. Draper, W. McKay, and S. Lees, "Instrument Engineering," in three volumes: Vol. I, 269 pp.; Vol. II, 732 pp.; Vol. III, not yet released, McGraw-Hill Book Co., Inc., New York, N. Y.; 1953.

Nuclear Control

Considerable information was published on the application of feedback control to nuclear reactors.

(884) R. V. Moore, "The control of a thermal neutron reactor," *Proc. IEE* (*London*), vol. 100, part I, pp. 90–101; May, 1953.
(885) J. H. Bowen, "Automatic control characteristics of thermal neutron reactors," *Proc. IEE* (*London*), vol. 100, part I, pp. 102–109; May, 1953.
(886) T. A. J. Jaques, H. A. Ballinger, and F. Wade, "Neutron detectors for reactor instrumentation," *Proc. IEE* (*London*), vol. 100, part I, pp. 110–116; May, 1953.

There are many basically new problems in nuclear-reactor control. The reactor is essentially nonlinear, making control difficult. The explosive nature of the reactor requires high performance and extremely high reliability of control.

(887) E. H. Wakefield, "Nuclear reactors for industry and research—III radiation measurement," *Instruments*, vol. 26, No. 11, pp. 1702–1704, 1750, 1752, 1754, 1756, 1758; November, 1953.

Aircraft Control

Some of the complex multiloop problems that exist in the application of new feedback techniques to the control of aircraft and guided missiles were described.

(888) W. G. Anderson and E. H. Fritze, "Instrument approach system steering computer," Proc. I.R.E., vol. 41, pp. 219–228; February, 1953.
(889) W. R. Monroe, "Improving the dynamic response of airplanes by means of electric equipment," *Applications and Industry*, no. 4, pp. 441–449; January, 1953.

Process Control

Process control has lagged considerably behind the servomechanism field in the application of new feed back control techniques. Most processes are so slow that high-performance controls are not needed. On the other hand, recent developments in the chemical industry created a need for faster controls, and new feedback control techniques were more widely applied.

(890) A. J. Young, "Control of chemical processes," *Instruments*, vol. 26, no. 1–8, (serial article); January–August, 1953.
(891) C. J. Swarthout, "An electronic approach to process control," *Instruments*, vol. 26, pp. 728–730, 750; May, 1953.
(892) L. A. Gould and P. E. Smith, Jr., "Dynamic behavior of pneumatic devices," *Instruments*, vol. 26, pp. 886–891, June, 1953; pp. 1026–1033, July, 1953.
(893) B. D. Stanton, "Instrument evaluation by frequency response," *Instruments*, vol. 26, pp. 745–749; May, 1953.

Varied Application of Feedback Control Techniques

Feedback control techniques were applied to a widening range of applications.

(894) W. K. Linvill and J. M. Salzer, "Analysis of control systems involving digital computers," Proc. I.R.E., vol. 41, pp. 901–906; July, 1953.
(895) D. G. Scorgie and D. H. Schaefer, "Stabilizing elements in aircraft d.c. systems," *Applications and Industry*, no. 4, pp. 387–397; January, 1953.
(896) A. W. Dickson, "Use of servo techniques in the design of amplitude stabilized oscillators," *Proc. N.E.C.*, vol. 8, pp.166–176; 1952.

Nonlinear Systems

Many papers were presented on the analysis and design of nonlinear feedback control systems. A number of nonlinear effects were examined and various methods for improving performance of systems were presented.

Study of Particular Nonlinear Effects

In two papers, many of the effects caused by saturation were considered. In another, an example was presented in which the analysis of coulomb friction by frequency response techniques led to an improvement in the design of an automatic milling machine.

(897) E. Levinson, "Some saturation phenomena in servomechanisms with emphasis on the tachometer stabilized system," *Applications and Industry*, no. 5, pp. 1–9; March, 1953.
(898) R. J. Kochenburger, "Limiting in feedback control systems," *Applications and Industry*, no. 7, pp. 180–184; July, 1953.
(899) V. B. Haas, Jr., "Coulomb friction in feedback control systems," *Applications and Industry*, no. 6, pp. 119–136; May, 1953.

Improving Response of Systems by Nonlinearities

The authors of two papers employed nonlinear techniques to improve the performance of nonlinear feedback control systems, while in a third paper, there was presented a nonlinear technique for improving a linear system.

(900) R. S. Neiswander and R. H. MacNeal, "Optimization of nonlinear control systems by means of nonlinear feedbacks," *Applications and Industry*, no. 8, pp. 262–272; September, 1953.
(901) K. C. Matthews and R. C. Boe, "The application of nonlinear techniques to servomechanisms," *Proc. N.E.C.*, vol. 8; 1952.
(902) J. W. Schwartz, "Piecewise linear servomechanisms," *Applications and Industry*, no. 4, pp. 401–405; January, 1953.

Nonlinear Analysis Techniques

The techniques that are most widely used in the analysis of nonlinear feedback control systems are the phase plane and the describing function. A recent paper strengthened the describing function tool by explaining its application to many different types of nonlinearities.

(903) H. D. Grief, "Describing function method of servomechanism analysis applied to most commonly encountered nonlinearities," *Applications and Industry*, no. 8, pp. 243–248; September, 1953.

An attempt was made to extend the phase plane approach.

(904) C. L. Kang and G. H. Fett, "Metrization of phase space and nonlinear servo systems," *Jour. Appl. Phys.*, vol. 24, pp. 38–41; January, 1953.

Use of Analog Computers in Nonlinear Systems

Because of the limitations of nonlinear analytical techniques for feedback control systems, a great many nonlinear problems are solved in practice by computers.

(905) C. A. Meneley and C. D. Morrill, "Applications of electronic differential analyzers to engineering problems," Proc. I.R.E., vol. 41, pp. 1487–1496; October, 1953.
(906) P. J. Hermann, "The design of a stabilized camera mount," *Proc. N.E.C.*, vol. 8, pp. 177–184; 1952.

Linear Theory

Despite the emphasis on nonlinear systems, substantial attention was given to linear feedback control theory.

(907) G. A. Biernson, "Quick methods for evaluating the closed-loop poles of feedback control systems," *Applications and Industry*, no. 6, pp. 53–70; May, 1953.
(908) S. J. Mason, "Feedback theory—some properties of signal flow graphs," Proc. I.R.E., vol. 41, no. 9, pp. 1144–1156; September, 1953.
(909) M. J. Kirby and D. C. Beaumariage, "Relative stability in closed-loop systems," *Applications and Industry*, no. 5, pp. 22–43; March, 1953.
(910) L. H. King, "Reduction of forced errors in closed-loop systems," Proc. I.R.E., vol. 41, pp. 1037–1042; August, 1953.

Components

Electrical: The important practical characteristics of many rotating electrical controls were described.

(911) S. Davis, "Rotating components for automatic control," *Product Eng.*, vol. 24, pp. 129–160; November, 1953.
(912) S. Davis, "Performance characteristics of the induction generator tachometer," *Product Eng.*, vol. 24, pp. 168–178; January, 1953.

Magnetic Amplifiers: Because of their basic ruggedness and high power output, magnetic amplifiers are well suited to feedback control and research in this direction was stimulated.

(913) H. H. Woodson, C. V. Thrower, and A. E. Schmid, Jr., "Compensation of a magnetic amplifier servo system," *Proc. N.E.C.*, vol. 8, pp. 158–165; 1952.

Hydraulic: One author presented an extensive analysis of the nonlinear effects in hydraulic valves concerning pressure-flow relations and forces on the valves, and two authors considered specific valve designs.

(914) J. F. Blackburn, "Contributions to hydraulic controls," *Trans. American Society of Mechanical Engineers*, vol. 75, no. 6, pp. 1163–1180; August, 1953.
(915) J. L. Bower and F. B. Tuteur, "Dynamic operation of a force-compensated hydraulic throttling valve," *Trans. American Society of Mechanical Engineers*, vol. 75, pp. 1395–1406; October, 1953.
(916) R. L. Scrafford, "Hydraulic servos incorporating a high-speed hydraulic-amplifier actuated valve," *Applications and Industry*, no. 7, pp. 175–180; July, 1953.

Practical Considerations in Design

The following papers dealt with design techniques involved in solving the practical problems in feedback control design.

(917) A. M. Fuchs, "Motor and gear train selection for automatic control systems," *Product Eng.*, vol. 24, pp. 128–133; March, 1953.
(918) J. Y. Kaplan, "Servo damping techniques," *Product Eng.*, vol. 24, pp. 193–198; October, 1953.

The problems of dynamic measurement were considered.

(919) F. H. Ferguson and C. H. Looney, "Transient measurement of feedback control systems," *Applications and Industry*, no. 6, pp. 110–114; May, 1953.
(920) R. J. Ehret, E. F. Hochschild, J. M. Embree, and E. C. Grogan, "An automatic transfer function measuring and recording system," *Communications and Electronics*, no. 9, pp. 664–669; November, 1953.
(921) P. R. Hoyt and B. D. Stanton, "Use of field test data for control system analysis," *Instruments*, vol. 26, no. 8, pp. 1180, 1181, 1216–1224; August, 1953.

Techniques for improving the performance of contactor feedback control systems were described:

(922) S. Davis, "Contactor amplifiers for automatic control," *Product Eng.*, vol. 24, pp. 186–194; March, 1953
(923) S. Davis and A. Gronner, "Circuits and applications of contactor control devices," *Product Eng.*, vol. 24, pp. 204–21; April, 1953.

Circuits

Communication circuits have become varied and complex and there was indication during 1953 of an increasing reliance on formal procedures for analysis and synthesis.

Fundamentals

Eight papers appeared whose chief objective was to shed new light on the foundations of circuit theory. The first five had a strong topological flavor, the last three fall more readily into a linear-algebra category.

A Dublin philosopher presented certain topological aspects of network theory which serve as the foundation of mesh analysis. Synge based his work on a Thevenin representation of a network consisting of impedances in series with constant voltage sources. To complete the picture, Saltzer developed a similar theorem based on a Norton representation of a network consisting of admittances in parallel with constant-current sources. The two papers form a unified background for the basic dual techniques of mesh and nodal analysis.

(924) J. L. Synge, "The fundamental theorem of electrical networks," *Quart. Appl. Math.*, vol. 9, pp. 113–127; July, 1951.
(925) C. Saltzer, "Second fundamental theorem of electrical networks," *Quart. Appl. Math.*, vol. 11, pp. 119–124; April, 1953.

A new method for solving networks was recommended. This method depends on certain fundamental properties of subnetworks called trees and two-trees that serve as components in functions called linkages. The major objective of this approach was to minimize the information redundancy prevailing in the determinant technique. After developing this powerful machinery the author proceeded to demonstrate its utility by demolishing with a flick of his pencil such a perennial problem as a twin-tee network loaded at both ends.

(926) W. C. Percival, "Solution of passive electrical networks by means of mathematical trees," *Proc. IEE (London)*, part 3, vol. 100, pp. 143–150; May, 1953.

A provocative paper undertook to formulate a set of principles and a systematic procedure for finding the exact solution of very large and complicated physical systems. The author claimed that by tearing the system into n pieces the required amount of machine calculation is reduced to about $2/n^2$.

(927) G. Kron, "A set of principles to interconnect the solutions of physical systems," *Jour. Appl. Phys.*, vol. 24, pp. 965–980; August, 1953.

Based on a penetrating study of the essentials of feedback theory, there was presented a kind of universal engineering language termed a "flow graph." The flow graph is an exceedingly simple and useful method for characterizing the equations of a physical system by a network of directed branches. Once the system is formulated as a flow graph, many relatively complicated relationships become obvious, and transformations and reductions can be readily made.

(928) S. J. Mason, "Feedback theory—some properties of signal flow graphs," PROC. I.R.E., vol. 41, pp. 1144–1156; September, 1953.

Emphasis was placed on the growing importance of linear vector algebra, especially as a means of separating the unsolved problems of network theory into the possible and impossible. A presentation was made of the necessary and sufficient conditions for physical realizability of an n-terminal network together with a formal method of realization. In the same general area, group theory was utilized to obtain the fundamental properties and a useful classification of networks. The author also stated necessary and sufficient conditions for the existence of a characteristic impedance.

(929) B. McMillan, "Introduction to formal realizability theory," *Bell Sys. Tech. Jour.*, vol. 31, pp. 217–279 and 541–600; March and May, 1952.
(930) M. G. Arsove, "Algebraic theory of linear transmission networks," *Jour. Franklin Inst.*, vol. 255, pp. 201–318; 427–444; April, May, 1953.

(931) R. Bott and R. J. Duffin, "On the algebra of networks," *Trans. Am. Math. Soc.*, vol. 74, pp. 99–109; January, 1953.

General Synthesis

An outstanding review of the key processes of network synthesis included a lucid explanation of fundamental concepts.

(932) E. A. Guillemin, "A summary of modern methods of network synthesis" in "Advances in Electronics," vol., 3, pp. 261–303; Academic Press, Inc., New York, N. Y.; 1951.

A careful balance between theory and practice was maintained in a presentation of the problem of realization of general two-terminal pairs. The methods include two reduction schemes and two extensions of existing techniques: reduction of complexity by breakdown of a Hurwitz polynomial into several parts, splitting a complicated transfer function into simple components, extension of Guillemin's zero-shifting methods to the complex plane, and extension of Bower and Ordung's RC methods to general lattice systems. It is to be hoped that further work will remove two restrictions, namely, lack of control over the flat loss, and assumption of constant-current sources.

(933) L. Weinberg, "New Synthesis Procedures for Realizing Transfer Functions of RLC and RC Networks," M.I.T. Research Laboratory of Electronics Report 201, 105 pp.; 1951.

One author, accomplished for the $2n$-pole what Brune did for a 2-pole, namely, synthesis with a minimum number of reactances and elements.

(934) B. D. H. Tellegen, "Synthesis of $2n$ poles of networks containing the minimum number of elements," *Jour. Math. Phys.*, vol. 32, pp. 1–18; April, 1953.

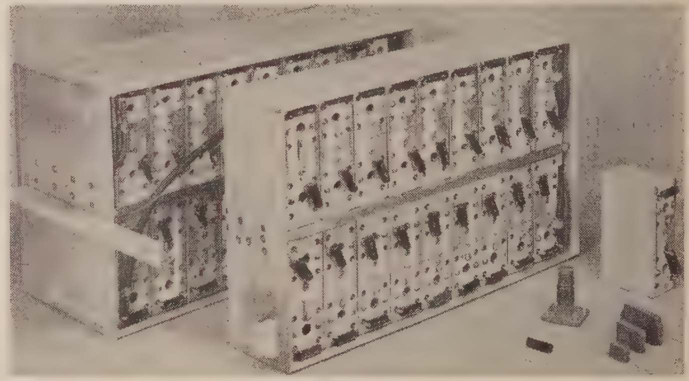
Several other papers offered valuable results in restricted areas of network synthesis. Foster's theorem was generalized using the Mittag-Leffler relation to show that the impedance of continuous structures can be represented exactly at all frequencies by a lumped-element network. This is accomplished by representing a transcendental function by an infinite series in a way analogous to the splitting of a rational function into partial fractions. It was found that filter functions can be represented in terms of a time power series to good advantage. Another author indicated how to synthesize a network to give prescribed magnitude-frequency characteristics by means of pole-zero pairs located on the real-p axis. A circle locus theorem was proposed as an aid in the design of impedance-matching networks.

(935) M. K. Zinn, "Network representation of transcendental impedance functions," *Bell Sys. Tech. Jour.*, vol. 31, pp. 378–404; March, 1952.
(936) J. L. Stewart, "Quasi-Distortionless Filter Functions," Stanford Electronics research Laboratories Report 64; May 25, 1953.
(937) A. D. Bresler, "On the approximation problem in network synthesis," Proc. I.R.E., vol. 40, pp. 1724–1728; Dec., 1952.
(938) L. Storch, "Theorem on the impedance transforming properties of reactive networks," *Jour. Appl. Phys.*, vol. 24, p. 833; July, 1953.
(939) R. Kahal, "Synthesis of the transfer function of 2-terminal pair networks," *Trans. A.I.E.E.*, vol. 71, pp. 120–134; April, 1952.

Two essentially tutorial papers, especially worthy of mention both for clarity and timeliness, presented some handy charts for the design of attenuation equalizers, and a translation into the language of engineering design of some of Darlington's classic work on insertion loss.

(940) F. R. Bies, "Attenuation equalizers," *Jour. Audio Eng., Soc.* vol. 1, pp. 125–136; January, 1953.
(941) L. Norde, "Modern methods of filter design," *Jour. Audio Eng. Soc.*, vol. 1, pp. 186–198; April, 1953.

For the serious student of network theory there is a good collection of 21 miscellaneous papers available as the proceedings of the symposium on modern network synthesis sponsored by Brooklyn Polytechnic Institute in April, 1952.



A battery-operated one-channel experimental television receiver in which the only vacuum tube is the kinescope. Transistors are used to perform all functions normally performed by receiving-type vacuum tubes. (RCA)

Tschebyscheff Polynomials

The need to solve the approximation or interpolation problem led to the development of a potent general method for finding frequency functions that approximate desired transmission characteristics.

(942) S. Darlington, "Network synthesis using Tschebyscheff polynomial series," *Bell Sys. Tech. Jour.*, vol. 31, pp. 613–655; July, 1952. Also, "Modern Network Synthesis," Brooklyn Polytechnic Institute, 1952.

Using this work as a base, other writers advanced on three fronts: (a) The consideration of low-pass structures particularly for interstage coupling; (b) the approximation of an arbitrary phase function over the low-pass interval where the flat delay is unspecified; also the Taylor approximation of arbitrary phase functions alone and both attenuation and phase functions for the band pass interval; (3) a solution of the open-circuit Tschebyscheff case, accomplished in the course of preparing a summary of the basic low-pass formulas published by designers using insertion parameter theory.

(943) V. Belevitch, "Tschebyscheff filters and amplifier networks," *Wireless Eng.*, vol. 29, pp. 106–110; April, 1952.
(944) V. H. Grinich, "On the approximation of arbitrary phase-frequency characteristics," Stanford Engineering Research Laboratory, Report 61; May 1, 1953.
(945) H. J. Orchard, "Formulae for ladder filters," *Wireless Eng.*, vol. 30, pp. 3–5; January, 1953.

Finally, a recent article presented a good introduction to Tschebyscheff polynomials.

(946) P. R. Clement, "The Tschebyscheff approximation method," *Quart. App. Math.*, vol. 11, pp. 167–183; July, 1953.

Potential Analog

The physical insight afforded by potential theory into the abstract behavior of electrical networks continued to intrigue a number of investigators. Many transformations were devised to adapt new and complicated problems to known and simple solutions, including the development of a general method for designing networks with arbitrary loss functions, and the formulation of the basis for a linear phase filter by juggling the network singularities to satisfy simultaneous loss and phase requirements.

(947) E. S. Kuh, "Potential analog network synthesis for arbitrary loss functions," *Jour. Appl. Phys.*, vol. 24, pp. 897–902; July, 1953. Also Stanford Electronics Research Laboratory, Report 44; February 14, 1952.

(948) B. J. Bennett, "Linear phase electric filters," Stanford Electronics Research Laboratory, Report 43, February 14, 1952. Also I.R.E. Convention Record 1953.

To meet a need for networks to provide a constant amplitude level over a band of frequencies, papers were published containing presentations of a "transfer function" and a "driving-point function." The approximation can be in either a Butterworth or Tschebyscheff sense.

(949) G. L. Matthaei, "Filter transfer function synthesis," Proc. I.R.E., vol. 41, pp. 377–382; March 1953. Stanford Electronics Research Laboratory, Report 39; August 31, 1951.

(950) E. M. Goldfarb, "The potential analogy as applied to a driving point immittance function," Stanford Electronics Research Laboratory, Report 56, 79 pp.; December 1, 1952.

In the initial stages of a study where high accuracy is not essential and flexibility is important, some time may be gained by the use of a special-purpose computer, presenting a visual display of the frequency characteristics from knowledge of the complex-plane singularities. In the infrequent cases of circuit application of potential theory where relaxation techniques are used, another paper offered more than usual freedom in choice of boundary conditions.

(951) J. R. Ragazzini and G. Reynolds, "Electronic complex plane scanner," *Rev. Sci. Inst.*, vol. 24, pp. 523–527; July, 1953.

(952) R. H. Macneal, "An asymmetrical finite difference network," *Quart. App. Math.*, vol. 11, pp. 295–310; October, 1953.

Resistance-Capacitance Networks

It seems that as long as considerable circuit activity continues at the low end of the frequency spectrum, the capacitor will remain the favorite energy storage element and engineers will restrict their designs to only one kind of reactance. This restriction imposes special problems which have been subjected to considerable scrutiny. A new general method was evolved for synthesis of RC transfer functions based on an extension of Brune's procedure for synthesis of driving-point impedances. Canonical sections were used for controlling transmission zeros in much the same way as they were utilized by Darlington in producing lossless two-terminal-pair networks.

(953) B. J. Dasher, "Synthesis of RC transfer functions as unbalanced two terminal-pair networks," M.I.T. Research Laboratory of Electronics, Report 215, 48 pp.; 1951. Also Trans. I.R.E., PGCT-1, December, 1952.

In an effort to dispel the notion that RC structures are always associated with loss, several writers have demonstrated that voltage gains of an assigned magnitude may be achieved at a given frequency.

(954) A. D. Fialkow and I. Gerst, "The maximum gain of an RC network," Proc. I.R.E., vol. 41, pp. 392–395; March, 1953.

(955) W. Bacon and D. P. Salmon, "Resistance capacitance networks with over unity gain," *Wireless Eng.*, vol. 30, pp. 20–23; January, 1953.

One team of authors developed a method of synthesis that cascades three terminal sections having real or complex zeros and real poles. Another paper recognized the shortcomings of physical embodiments of mathematical designs and strove to calculate the departure-due to nonideal components, of the actual network behavior from the design characteristics.

(956) P. F. Ordung et al., "Synthesis of cascaded three terminal RC networks with minimum phase transfer functions," Proc. I.R.E., vol. 40, pp. 1717–1723; December, 1952.

(957) C. Belove, "Tolerance coefficients for R-C networks," *Jour Appl. Phys.*, vol. 24, pp. 745–747; June, 1953.

(958) L. G. Cowles, "The parallel T resistance capacitance network," Proc. I.R.E., vol. 40, pp. 1712–1717; December, 1952.

The scope and maturity of the field of microwave circuits is evidenced by a recently-published book.

(959) H. J. Reich, P. F. Ordung, H. L. Krauss, and J. G. Skalnik, "Microwave Theory and Techniques," D. Van Nostrand Co., Inc., New York, 1953.

Several new ideals relative to nonreciprocal devices such as the gyrator were advanced. Two articles considered the Faraday effect: One dealt with a ferromagnetic medium, while the other employed a dielectric medium. By careful examination of the implications of the gyrator equations, the author of a third paper disclosed how to realize an element analogous to a gyrator with a unilateral transducer.

(960) C. L. Hogan, "The ferromagnetic effect at microwave frequencies and its applications—the microwave gyrator," *Bell Sys. Tech. Jour.*, vol. 31, pp. 1–31; January, 1952.

(961) L. Goldstein and M. A. Lampert, "New linear passive nonreciprocal microwave circuit component," Proc. I.R.E., vol. 41, pp. 295–296; February, 1953.

(962) J. Shekal, "The gyrator as a three terminal element," Proc. I.R.E., vol. 41, pp. 1014–1016; August, 1953.

As in the video regions of circuit theory, strong interest in phase devices was evidence by a paper which described a delay circuit obtained by using variations in guide length and differences in cut-off frequency of the guides. A similar effect was accomplished by movement of dielectric material within the guide.

(963) H. Sohon, "Wide band phase delay circuit," Proc. I.R.E., vol. 41, pp. 1050–1052; August, 1953.

(964) G. J. Halford, "A wide-band waveguide phase-shifter," *Proc. I.E.E. (London)*, vol. 100, part 3, no. 65, pp. 117–124; May, 1953.

The coaxial line was shown to be useful in low-pass ladder structures at hyper frequencies.

(965) D. E. Mode, "Coaxial transmission line filters," Proc. I.R.E. vol. 40, pp. 1706–1711; December, 1952.

Nonlinear Circuits

Three papers emphasized the fundamentals and logical structure of nonlinear circuits. It was proposed that the theory should be developed to take full advantage of the high-speed computing machinery now available. The proceedings of the "Symposium on nonlinear circuit analysis," sponsored by Brooklyn Polytechnic Institute in April, 1953, when published, will provide a wealth of additional material.

(966) L. A. Zadeh, "Nonlinear multipoles," *Proc. Nat. Acad. Sci.*, vol. 39, pp. 274–280; April, 1953.
(967) L. A. Zadeh, "Optimum nonlinear filters," *Jour. Appl. Phys.*, vol. 24, pp. 396–404; April, 1953.
(968) L. A. Zadeh, "Contribution to the theory of nonlinear systems," *Jour. Franklin Inst.*, vol. 255, pp. 387–408; May, 1953.
(969) W. B. Wrigley, "A note on moving poles in nonlinear oscillating system," Proc. I.R.E., vol. 41, pp. 774–777; June, 1953.
(970) N. Minorsky, "On the interaction of non-linear oscillations," *Jour. Franklin Inst.*, vol. 256, pp. 147–165; August, 1953.
(971) J. S. Thomsen, "Graphical analysis of nonlinear circuits using impedance concepts," *Jour. Appl. Phys.*, vol. 24, pp. 1379–1382; November, 1953.

Amplifiers

Only a few traces remain of the old philosophy of regarding the active and passive portions of an amplifier as separate domains to be individually designed and eventually joined as a final step. In fact, the two have now coalesced in such embodiments as the traveling-wave tube and the distributed amplifier so as to make any separation impossible. In particular, the distributed amplifier, which is based on artificial-transmission-line theory, received considerable attention. One author chose a building-block technique in which a circuit using two tubes was designed as a unit and termed a distributed pair. Using matrix algebra, a detailed analysis of the operation of the plate line of a distributed amplifier was published.

(972) D. O. Pederson, "The distributed pair," Trans. I.R.E., PGCT-1; December, 1952. Also Stanford Electronics Research Laboratory, Report 70, 21 pp.; October 5, 1953.
(973) A. D. Moore, "Synthesis of distributed amplifiers for prescribed amplitude response," Stanford Electronics Research Laboratory, Report 53, 93 pp.; September 1, 1952.
(974) D. V. Payne, "Distributed amplifier theory," Proc. I.R.E., vol. 41, pp. 759–762; June, 1953.

A generalized graphical approach to the synthesis of band-pass amplifiers was evolved using conventional interstage coupling networks. Turning to a more specific problem, another worker found that the tubes in a grounded-grid cascade act as impedance transformers with low input and high output impedances so that the coupling networks must behave like current transformers in order to provide gain.

(975) D. L. Trautman, "Maximally flat amplifiers of arbitrary bandwidth and coupling," Stanford Electronics Research Laboratory, Report 41, 94 pp.; February 1, 1952.
(976) W. A. Christopherson, "Analysis and synthesis of grounded grid amplifier transfer functions," Stanford Electronics Research Laboratory, Report 46, 108 pp.; May 12, 1952.
(977) M. M. McWhorter, "The design, physical realization, and transient behavior of double tuned amplifiers of arbitrary-bandwidth," Stanford Electronics Research Laboratory, Report 58; 103 pp., February 9, 1953.
(978) H. Hsu, "On transformations of linear active networks with applications at ultra-high frequencies," Proc. I.R.E., vol. 41, pp. 59–67; January, 1953.

Transistor Circuits

A milestone in the development of transistor circuits was passed with the publication of the first book on the subject. A series of articles contained a large collection of tutorial information and covered both the circuit aspects and physics of transistors.

(979) R. F. Shea, editor, "Principles of Transistor Circuits," John Wiley and Sons, New York, 1953.
(980) A. Coblenz and H. Owens, "Transistors, theory and applications," *Electronics*, vol. 26, pp. 98–102; 138–141; 162–165; 166–171; 158–163; 156–161; 156–161; 158–163; 166–172; March through November, 1953.

It was observed that by recognizing the complementary nature of the *n-p-n* and *p-n-p* transistors and by proper association of the two types, one could eliminate the need for certain subsidiary circuit elements. A circuit which has an output impedance that is the negative of the source opened up a whole new vista of applications. One paper presented the design problem of trigger circuits.

(981) G. C. Sziklai, "Symmetrical properties of transistors and their applications," Proc. I.R.E., vol. 41, pp. 717–724; June, 1953.
(982) J. G. Linvill, "Transistor negative impedance converters," Proc. I.R.E., vol. 41, pp. 725–729; June, 1953.
(983) F. C. Williams, "A method of designing transistor trigger circuits," *Proc. IEE* (*London*), part 3, vol. 99, pp. 228–248; July, 1953.

One modern philosophy of high-speed computer design holds that the logic functions should be implemented by passive devices and that transistors should be employed only for gain. A pulse amplifier to meet such a need was described in one article.

(984) J. H. Vogelsong, "A transistor pulse amplifier using external regeneration," Proc. I.R.E, vol. 41, pp. 1444–1450; October, 1953.
(985) R. H. Baker et al., "The phase bistable transistor circuit," Proc. I.R.E., vol. 41, pp. 1119–1124; September, 1953.
(986) W. F. Chow and J. J. Suran, "Transient analysis of junction transistor amplifiers," Proc. I.R.E., vol. 41, pp. 1125–1129; September, 1953.
(987) G. C. Sziklai, R. D. Lohman, and G. B. Herzog, "A study of transistor circuits for television," Proc. I.R.E., vol. 41, pp. 708–717; June, 1953.
(988) G. Knight, Jr., R. A. Johnson, and R. B. Holt, "Measurement of small signal parameters of transistors," Proc. I.R.E., vol. 41, pp. 983–989; August, 1953.
(989) P. G. Sulzer, "Low distortion transistor audio oscillator," *Electronics*, vol. 26, pp. 171–173; September, 1953.
(990) F. R. Stansel, "The common-collector transistor amplifier at carrier frequencies," Proc. I.R.E., vol. 41, pp. 1096–1102; September, 1953.
(991) B. J. O'Neill and A. Gutterman, "Methods and equipment for transistor testing," *Electronics*, vol. 26, pp. 172–175; July, 1953.
(992) L. J. Giacoletto, "Terminology and equations for linear active four-terminal networks including transistors," *RCA Review* vol. 14, pp. 28–46; March, 1953.

A comprehensive story on the synthesis problem was contained in a report which approached the problem from three different viewpoints. The first described a new method of expansion in orthogonal functions leading to Laguerre or Legendre polynomials. This does not restrict the poles to the negative real axis. Method two employed saddle-point integration to determine the sensitive regions of the complex plane. In the third procedure, using "constituent transients," considerable resourcefulness was exhibited in obtaining rational approximations to the required Laplace transforms in closed form.

(993) W. H. Kautz, "Network synthesis for specified transient response," M.I.T. Research Laboratory of Electronics, Report 209, 177 pp.; 1952.

One author resurrected the 1795 work of a French mathematician to help in approximating prescribed functions in the time domain by means of a sum of exponential functions or a damped Fourier series. Optimum transient response on the basis of rise time and overshoot was the objective of another author who synthesized a series of all-pole systems. Using fixed power and fixed over-all distortion, a third author indicated the optimum transmitter and receiver transfer characteristics.

(994) A. D. Moore, "An application of Prony's method to time domain network synthesis," Stanford Electronics Research Laboratory, Report 42, 49 pp.; February 1, 1952.
(995) G. W. Mathers, "The synthesis of lumped-element circuits for optimum transient response," Stanford Electronics Research Laboratory, Report 28, 131 pp.; November 1, 1951.
(996) R. S. Berkowitz, "Optimum linear shaping and filtering networks," Proc. I.R.E., vol. 41, pp. 532–537; April, 1953.

Equalization in the time domain was the principal theme of a group of articles in British journals. In brief, the central idea is that the transfer characteristics of nearly all forms of linear four-terminal networks may be equalized by adding to the response, successive derivatives of integrations with respect to time. A strong feature of this approach is that it may be applied to systems for which the equivalent four-terminal passive network is nonrealizable.

(997) C. G. Gouriet, "Spectrum equalization," *Wireless Eng.*, vol. 30, pp. 112–113; May, 1953.
(998) J. M. Linke, "A variable time-equalizer for video-frequency waveform corrections," *Proc. IEE* (*London*), vol. 29, part 3A, no. 18; 1952.
(999) W. E. Thomson, et al., "Synthesis of a network to have a sine-squared impulse response," *British Post Office Research Report No. 13529;* December, 1951. Also *Proc. IEE* (*London*), vol. 99, part 3, pp. 373–376; November, 1952.
(1000) W. E. Thomson, "Networks with maximally flat delay," *Wireless Eng.*, vol. 29, pp. 256–263; October, 1952.
(1001) One published paper dealt with filtering in the time domain. H. Urkowitz, "Filters for detection of small radar signals in clutter," *Jour. Appl. Phys.*, vol. 24, pp. 1024–1031; August, 1953.

Transient Response-Analysis

By the application of information theory concepts, two authors further developed the theory of time series for transient analysis and stressed its convenience and simplicity. The underlying principle used is that any waveform arising from a system of limited bandwidth can be represented exactly by a time sequence of equidistant ordinates having an interval equal to half the reciprocal of the bandwidth.

(1002) W. E. Thomson, "A theory of time series for waveform transmission systems," *Proc. IEE* (*London*), vol. 99, part 4, no. 4, pp. 397–409; December, 1952.
(1003) N. W. Lewis, "Waveform computations by the time-series method," *Proc. IEE* (*London*), vol. 99, part 3, no. 61, pp. 294–306; September, 1952.

The signal-to-noise ratio of a periodic signal was improved by a time-domain filter which commutates the signal to a bank of capacitors through a series resistor. It was found that the response of a passive network to a step sinusoid gives results not restricted to narrow bands. A solution was also presented of the response of a series-loaded parallel-tuned circuit to a linearly increasing driving force.

(1004) W. R. LePage et al., "Analysis of a comb filter using synchronously commutated capacitors," *Trans. AIEE, Communication and Electronics No. 5*, pp. 63–68; March, 1953.
(1005) A. W. Gent, "The transient response of R.F. and I.F. filters to a wave packet," *Proc. IEE* (*London*), part 4, vol. 99, pp. 326–335; December, 1952.
(1006) M. S. Corrington, "Response of a tuned circuit to a ramp function," Proc. I.R.E, vol. 41, pp. 660–664; May, 1953.
(1007) J. F. Koenig, "On the zeros of polynomials and the degree of stability of linear systems," *Jour. Appl. Phys.*, vol. 24, pp. 476–482; April, 1953.

Video Techniques

Historical notes on the development of the science and techniques of television were authoritatively presented.

(1008) V. K. Zworykin, "Evolution in television," *Elec. Eng.*, vol. 72, p. 209; March, 1953.

The trend toward fundamental analyses of the factors affecting picture quality and resolution in both photography and television continued.

(1009) O. H. Schade, "Image gradation, graininess and sharpness in television and motion picture systems, Part 3. The grain structure of television images," *Jour. Soc. Mot. Pic. & Telev. Eng.*, vol. 61, pp. 97–164; August, 1953.
(1010) R. N. Wolfe and F. C. Eisen, "Psychometric evaluation of sharpness of photographic reproductions," *Jour. Soc. Mot. Pic. & Telev. Eng.*, vol. 61, p. 590; November, 1953.
(1011) G. C. Higgins and L. A. Jones, "The nature and evaluation of the sharpness of photographic images," *Jour. Phot. Sci. and Tech.*, vol. 19B, p. 55; 1953.

Techniques were sought whereby elimination of the redundancy in television picture signals would permit a reduction in transmission bandwidth, or an increase in the quality of pictures transmitted over present systems.

(1012) E. C. Cherry and G. G. Gouriet, "Some possibilities for compression of television signals by recoding," *Proc. IEE* (*London*), vol. 100, part 3, p. 9; January, 1953.
(1013) "Saving television bandwidth," *Wireless World*, vol. 59, p. 159; April, 1953.

The techniques for better use of available bandwidths were developed for color television and provided significant improvements in quadrature cross talk, interference, and the choice of chromatic information.

(1014) R. D. Kell and A. C. Schroeder, "Optimum utilization of the RF channel for color TV," *RCA Rev.*, vol. 14, p. 133; June, 1953.

IRE proposed standards on measurement of sweep linearity, and of geometric distortion. The RETMA standard on television studio facilities, including a linearity chart, was released. Other work dealt with methods of measuring frequency response, and amplitude nonlinearity. Several test equipments were described.

(1015) C. H. Moulton, "Test scope checks television broadcasts," *Electronics*, vol. 26, p. 139; January, 1953.
(1016) R. Moffett, "Signal-noise meter checks television links," *Electronics*, vol. 26, p. 164; October, 1953.
(1017) E. M. Buyer, "Line selector checks television waveforms," *Electronics*, vol. 26, p. 153; September, 1953.
(1018) I. C. Abrahams and R. C. Thor, "A precision line selector for television use," *Convention Record IRE, part 4*, p. 45; 1953.
(1019) R. Moffett, "Television transmission test equipment." Presented at *7th NARTB Eng. Conf.*, Los Angeles, Calif.; April, 1953.

The advent of color television stimulated development of test equipment especially for measurement of phase response, phase modulation, and envelope delay.

(1020) W. L. Firestone and R. A. Richardson, "Simplified Vectorscope measures phase," *Electronics*, vol. 26, p. 180; September, 1953.
(1021) C. E. Page, "A monitoring system for NTSC color television signals," *Convention Record IRE*, part 4, p. 61; 1953.
(1022) A. P. Stern, "Phase measurements at subcarrier frequency in color television," *Convention Record IRE*, part 4, p. 57; 1953.

Improved techniques for video-signal transmission over coaxial cables were described.

(1023) C. H. Elmendorf and R. D. Ehrbar, R. H. Klie and A. J. Grossman, "L3 system design," *Bell Sys. Tech. Jour.*, vol. 32, p. 781; July, 1953.
(1024) R. W. Ketchledge and T. R. Finch, "L3 equalization and regulation," *Bell Sys. Tech. Jour.*, vol. 32, p. 833; July, 1953.
(1025) L. H. Morris, G. H. Lovell, and F. R. Dickinson, "L3 amplifiers," *Bell Sys. Tech. Jour.*, vol. 32, p. 879; July, 1953.
(1026) J. W. Reike and R. S. Graham, "L3 television terminals," *Bell Sys. Tech. Jour.*, vol. 32, p. 915; July, 1953.

NTSC color-television signals were transmitted over a narrow-band 2.7-mc cable system by heterodyning the color subcarrier to a lower frequency within the band and then restoring it to the normal frequency at the other end of the cable.

(1027) G. G. Reddeck and H. C. Gronberg, "Color television converter for cable networks," *Electronics*, vol. 26, p. 132; November, 1953.

Image orthicon film pickups were successfully used. Vidicon cameras for television film use were demonstrated.

(1028) R. D. Chipp, "Film projection using image orthicon cameras," *Jour. Soc. Mot. Pic. & Telev. Eng.*, vol. 60, p. 1; January, 1953.
(1029) H. N. Kozanowski, "Vidicon for television film reproduction," Presented at National Electronics Conference; September, 1953.

New types of continuous-motion projectors for use with flying-spot scanners were described for both black-and-white and color film pickups. A multisided rotating prism was used to maintain a stationary film image. Also it was shown that the jump-scan system will accommodate itself to a continuously moving image.

(1030) E. H. Traub, "A television film scanner using continuous film motion." Presented at 7th NARTB Eng. Conf., Los Angeles; April, 1953.
(1031) V. Groziano and K. Schlesinger, "A continuous all-electronic scanner for 16 mm color motion picture film." Presented at National Electronics Conference; September, 1953.

A fast-pull-down projector for 16-mm color film was demonstrated with a flying-spot scanner. Two more-conventional types of television projectors for 16-mm monochrome film featured improved techniques.

(1032) W. E. Stewart, "New professional television projector," *Jour. Soc. Mot. Pic. & Telev. Eng.*, vol. 61, p. 390; April, 1953.
(1033) R. E. Putnam and E. H. Lederer, "Synchro-lite powered 16 mm projector," *Jour. Soc. Mot. Pic. & Telev. Eng.*, vol. 61, p. 385; April, 1953.

An article on a large-screen projection system described new techniques in achieving light-valve type operation and permitting high screen brightness through the use of arc lamps.

(1034) E. I. Sponable, "Eidophor system of theater television," *Jour. Soc. Mot. Pic. & Telev. Eng.*, vol. 61, p. 237; April, 1953.

Stereoscopic black-and-white television was demonstrated at the NARTB Convention in Los Angeles, April 28, 1953. A rotating, segmented mirror was used as an optical switch to pick up the scene in a single image-orthicon camera along each of two viewing angles on successive fields. Two separate picture tubes with inputs keyed at the field rate, projected images on a screen through polarized filters; the audience wore polaroid glasses.

Final reports on color television of the National Television System Committee, Panel 12 included 14 comprehensive technical monographs, that were issued in a single publication.

(1035) National Television System Committee, Report of Panel 12, "Color system analysis," PROC. I.R.E., vol. 42, p. 15; January, 1954.

Experimental video tape recording systems were demonstrated, with both color and black-and-white signals. One system used 12 tracks on tape running at 8⅓ feet per second. Another system used 2-track ¼-inch tape for monochrome and 5-track ½-inch tape for color, both running at 30 feet per second.

Audio Techniques

The year was highlighted by a rapidly developing interest in high-fidelity sound reproduction and in stereophonic techniques for both theatre and home sound systems.

High-Fidelity Sound Reproduction

Only recently has high-fidelity reproduction of sound captured the imagination of the public at large. In 1953 it became a big industry.

There were technical improvements in most high-fidelity components. Several manufacturers introduced very compact, completely packaged and moderately priced high-fidelity phonographs. These equipments, while hardly challenging the results possible from a well-engineered custom assembly of the highest-quality components, gave a surprisingly good performance that the buying public was quick to appreciate.

An authoritative and quantitative summary of the factors involved in high-fidelity sound reproduction was published as was a book on the subject. Another paper described the development and design of one of the new high-fidelity phonographs in which pleasing sound quality was achieved at relatively low cost.

(1036) H. F. Olson, "Matched line of Hi-Fi equipment," *Audio Eng.*, vol. 37, pp. 29–31, 53; August, 1953.
(1037) H. D. Weiler, "High Fidelity Simplified," John F. Rider Publisher, New York, N. Y., 1953 (Reviewed PROC. I.R.E., vol. 41, p. 1198; September, 1953).
(1038) P. C. Goldmark, "The Columbia '301,' " *Audio Eng.*, vol. 37, pp. 28–29, 59; March, 1953.

Significantly, the Radio-Electronic-Television Manufacturers Association established a technical committee on high-fidelity sound systems.

(1039) F. A. Slaymaker, "RTMA SE-8 committee on high fidelity sound systems," *Trans. I.R.E. Professional Group on Audio*, vol. AU-1, p. 3; September–October, 1953.

Stereophonic Sound

Stereophonic sound techniques were adopted widely by the motion picture industry as a logical accompaniment to the three-dimensional and expanded-screen types of picture presentation. Magnetic recording almost completely displaced optical recording of sound in this industry. The magnetic medium is particularly well adapted to the multichannel requirements of stereophonic sound. A summary paper including 68 references points out the fundamental differences between ordinary binaural listening and stereophony and the practical applications of stereophony for both theatre and home.

(1040) W. B. Snow, "Basic principles of stereophonic sound," *Jour. Soc. Mot. Pic. & Telev. Eng.*, vol. 61, pp. 567–589; November, 1953.

(1041) C. G. McProud, "Two-channel conversion for FM receivers," *Audio Eng.*, vol. 37, pp. 25–27; January, 1953.

(1042) M. G. Crosby, "Binaural sound on one FM channel,"*TV and Radio Engineering;* August–September, 1953.

There were new developments in both disc and magnetic equipment for home stereophonic systems. Law enforcement agencies made use of binaural techniques for surreptitious recording, since this method permits much greater intelligibility in the presence of masking noises and reverberation. Binaural recording was also found to be of considerable value in court room reporting, especially in situations where several people were talking at once.

(1043) O. C. Bixler, "A practical binaural recording system," *Trans. I.R.E. Professional Group on Audio*, vol. AU-1, pp. 14–22; January–February, 1953.

(1044) R. H. Snyder, "History and development of stereophonic sound recording," *Jour. Audio Eng. Soc.*, vol. 1, pp. 176–179; April, 1953.

(1045) P. C. Goldmark, "The Columbia XD (extra dimensional) sound system," *Audio Eng.*, vol. 37, pp. 36, 38, 115–116; October, 1953.

Audio Systems

Several new broadcasting studio audio installations were described. There was a continuing trend toward increased and more-complex audio facilities in television studios. Illustrative of present-day techniques was a recent paper describing the audio facilities portion of a large television broadcasting plant in Hollywood, California.

(1046) H. A. Chinn, R. B. Monroe, and C. A. Palmquist, "CBS Television City audio facilities." Presented at Audio Engineering Society Convention; October, 1953.

The increasing size and complexity of television stages introduced problems not only of sound pickup but also of sound reinforcement on the stage itself. The necessity of creating a favorable acoustical environment for television actors by means of special on-stage sound reinforcement facilities was described.

(1047) R. H. Edmondson, "On-stage selective sound reinforcement system." Presented at Audio Engineering Society Convention; October, 1953.

The design and installation of sound reinforcing facilities for the new Plenary Hall of the General Assembly Building of the United Nations, in New York City presented a challenging problem in audio engineering. The principal design requirements were intelligibility, naturalness, concealment, and freedom from feedback when operated at required sound levels. Satisfactory speech intelligibility was obtained by faithful reproduction of the frequency range between 300 and 6,000 cps, freedom from nonlinear distortion, uniform coverage of the hall at all frequencies, and by a suitable employment of time delay systems.

(1048) C. W. Goyder and L. L. Beranek, "Sound system for plenary hall of United Nations general assembly building," Convention, Part 3-Audio, pp. 26–40; 1953.

Military Audio

The Air Force developed a completely new high-intelligibility interphone equipment which is effective under the very-high noise found in today's aircraft. Another military application was the so-called "voice plane" used in Korea for psychological warfare. This is a medium bomber fitted with four 500-watt amplifiers and a multiple-driver horn-type loudspeaker. Such planes are capable of delivering a message to a given place on the ground for approximately thirty seconds while flying at an altitude out of accurate range of small-weapons fire.

(1049) P. J. Weber, "Status of military research and development in acoustics and radio," *Trans. I.R.E. Professional Group on Audio*, vol. AU-1, pp. 4–15; May–June, 1953.

Audio Components

Several new microphones were developed, reflecting the continuing trend toward small and unobtrusive units. The unidirectional type of microphone, which is indispensible for television boom use, was substantially reduced in size and improved in directional characteristics. One type of condenser microphone now has directional characteristics that may be varied continuously and remotely.

(1050) H. F. Olson, J. Preston, and J. C. Bleazey, "The uniaxial microphone," *RCA Rev.*, vol. 14, pp. 47–63; March, 1953.

(1051) F. W. O. Bauch, "New high grade condenser microphones," *Wireless World*, vol. LIX, pp. 50–54; February, 1953.

A new and greatly expanded edition of a well-known reference book devoted more than 400 pages to various phases of audio engineering.

(1052) F. Langford-Smith, "Radiotron Designers Handbook," Amalgamated Wireless Valve Company Pty, Ltd., Sydney, Australia; 4th ed.; 1952; published in U.S.A. by Radio Corp. of America, Harrison, N. J.; 1953.

The only commercial usage of transistors in audio equipment reported was in hearing aids in which the junction type was used exclusively. Some hearing aids use transistors in the output stage only, but at least one manufacturer uses them throughout. The reduction in battery costs tended to make up for higher equipment costs compared to vacuum tube instruments. Printed circuits found increasing usage in hearing aids.

(1053) J. D. Fahnenstock, "Transistorized hearing aid," *Electronics*, vol. 26, pp. 154–155; April, 1953.

(1054) J. Kanarek, "The application of printed circuits and miniaturized assemblies to audio amplifiers and equipment," *Jour. Aud. Eng. Soc.*, vol. 1, pp. 202–207; April, 1953. A large portion of the first textbook on applications of transistors is devoted to audio and low-frequency uses.

(1055) R. F. Shea, "Principles of Transistor Circuits," John Wiley and Sons, Inc., New York, N. Y.; 1953.

Audio Measurements

The search continued for more-definitive methods of measuring the performance of audio equipment. The harmonic method was adequate for evaluating the performance of wide-band broadcasting facilities. The difference-tone method was reported to be effective in uncovering nonlinear distortion in loudspeakers. The intermodulation method recommended by the International Telephone Advisory Committee (CCIF) was found to be the most suitable method for evaluation of high-frequency nonlinearity in systems having sharply restricted high-frequency response. The method of measuring intermodulation distortion recommended by the Society of Motion Picture and Television Engineers was found to provide primarily a measure of only low-frequency distortion.

(1056) D. E. Maxwell, "Comparative study of methods for measuring non-linear distortion in broadcasting audio facilities" *Jour. Aud. Eng. Soc.*, vol. 1, pp. 68–78; January, 1953.
(1057) F. Ingerslev, "Nonlinear distortion in loudspeakers." Presented at International Electro-Acoustics Congress, Netherlands; June, 1953.
(1058) H. H. Scott, "Intermodulation measurements," *Jour. Aud. Eng. Soc.*, vol. 1, pp. 56–61; January, 1953.
(1059) E. Cook, "Significance of intermodulation of high frequencies in audio equipment," Presented at Audio Engineering Convention, October, 1953; to appear, *Jour. Aud. Eng. Soc.*, January, 1954.
(1060) H. E. Roys, "Distortion in phonograph reproduction," *Jour. Audio Eng. Soc.*, vol. 1, pp. 78–85; January, 1953. Also *RCA Rev.*, vol. 14, pp. 397–412; September, 1953.

Receivers

Television Receivers

A major development in the field of home-entertainment receivers during the year 1953 was the appearance of practical color television receivers designed to operate in accordance with the proposed NTSC signal specifications. Preparations were made for the production of these receivers upon formal approval of the proposed standards. This approval was announced by the Federal Communications Commission on Dec. 17, 1953.

Many improvements and simplifications in the receiver were made, particularly in the color kinescope and its associated circuits as the result of the extensive NTSC field test program.

(1061) Second Special Issue on Color Television, Proc. I.R.E.; January, 1954.
(1062) Standards on Television: Definitions of Color Terms, Part 1, 1953, Proc. I.R.E., vol. 41, pp. 344–347; March, 1953.
(1063) R. D. Kell and A. C. Schroeder, "Optimum utilization of the radio frequency channel for color television," *RCA Rev.*, vol. 14, pp. 133–143; June, 1953.
(1064) G. H. Brown and D. G. C. Luck, "Principles and development of color television systems," *RCA Rev.*, vol. 14, pp. 144–204; June, 1953.
(1065) D. H. Pritchard and R. N. Rhodes, "Color television signal receiver demodulators," *RCA Rev.*, vol. 14, pp. 205–226; June, 1953.
(1066) C. J. Hirsch and B. D. Loughlin, "General color-receiver design considerations," Inst. Radio Engrs.-Trans. of Professional Group on Broadcasting and Television Receivers, PGBTR-2, March, 1953.
(1067) L. H. Horn, "Connection of uhf and color adaptors to vhf receivers," I.R.E. Trans. of Professional Group on Broadcasting and Television Receivers, PGBTR-2, March, 1953.
(1068) K. E. Farr, "Compatible color television receiver," *Electronic*, vol. 26, pp. 98–104; January, 1953.
(1069) D. G. Fink, "What design engineers need to know about the NTSC color television standard," *Electronics*, vol. 26, pp. 138–150; December, 1953.

Monochrome television receiver developments consisted mainly of refinements in existing circuits and the application of known circuit techniques to obtain improved performance at lower cost. Many of the changes were to incorporate new types of tubes made specifically for television circuits. Industry use of the standard 41.25–45.75 mc IF was more widespread than in previous years, with the ten major manufacturers employing it in all their models. Particular emphasis was placed on improving picture quality and operation in fringe areas.

(1070) A. Macovski, "A keyed minimum signal detector for television receiver impulse-noise immunity," *RCA Rev.*, vol. 14, pp. 389–396; September, 1953.
(1071) G. W. Preston and J. C. Tellier, "Lock-in performance of afc circuit," Proc. I.R.E., vol. 41, pp. 249–251; February, 1953.
(1072) W. J. Gruen, "Theory of afc synchronization," Proc. I.R.E., vol. 41, pp. 1043–1048; August, 1953.
(1073) W. J. Gruen, "Instrumentation for experimental investigation of afc systems." Presented at the IRE/RETMA Fall Meeting; October, 1953.
(1074) E. S. White, "Television receiver agc systems," *Electronics*, vol. 26, pp. 146–149; March, 1953.
(1075) J. Avins, J. S. Horvath, and B. Harris, "Improving the transient response of television receivers," Proc. I.R.E., vol. 42, pp. 274–284; January, 1954.
(1076) G. D. Hulst, "Design of television receivers utilizing nonsynchronous power," I.R.E.-Trans. of Professional Group on Broadcasting and Television Receivers, PGBTR-3, pp. 15–24; June, 1953.

Radiation and Interference

A preliminary standard for the measurement of horizontal-sweep-circuit radiation from television receivers was a significant step toward the reduction of radiation below 10 mc. A screened-room technique is employed in contrast to the open-field method used for measuring vhf-uhf oscillator radiation.

The trend toward the reduction of oscillator radiation in both the vhf and uhf range continued. The I.R.E. standard for the measurement of receiver oscillator radiation was extended to include uhf.

It was found that bilateral interference between color receivers and amateur communications could be minimized by proper television receiver design without exceeding reasonable economic or engineering limits.

(1077) IRE Subcommittee 17.4, Preliminary Standard: Measurement of Sweep Radiation.
(1078) Supplement No. 2, "Vhf-uhf antenna construction," to Standard 51 IRE 17.S1; "Standards on radio receivers open field method of measurement of spurious radiation from frequency modulation and television broadcast receivers, 1951."
(1079) L. M. Clement, "Television receiver interference: Industry record to date." Presented at the IRE/RETMA Fall Meeting; October, 1953.
(1080) S. L. Bailey, "Measurements and standards for the control of spurious radiation." Presented at the IRE-RETMA Fall Meeting; October, 1953.
(1081) K. A. Chittick, "Spurious radiations from television receivers." Presented at the IRE-RETMA Fall Meeting; October, 1953.
(1082) P. S. Rand, "Reducing the radiation from television receivers," *Electronics*, vol. 26, pp. 130–135; May, 1953.
(1083) D. G. Fink, "Industry-wide cooperation with the JTAC spurious radiation program." Presented at the IRE/RETMA Fall Meeting; October, 1953.
(1084) E. I. Anderson and G. Grammer, "Color television an the radio amateur." Presented at the IRE/RETMA Fall Meeting; October, 1953.
(1085) G. L. Fredendall, "A comparison of monochrome and color television with reference to susceptiblity to various types of interference," *RCA Rev.*, vol. 14, pp. 341–357; Sept., 1953.

Ultra-High Frequency Television

The use of converters and converter strips decreased considerably in favor of combination uhfvhf tuners. The commercial application of rf amplifier tubes at uhf was still in the developmental stage, the conventional design consisting of a tuned preselector followed by a crystal mixer.

(1086) W. Y. Pan, "Investigation of uhf television amplifier tubes." Presented at the IRE/RETMA Fall Meeting; October, 1953.
(1087) W. P. Boothroyd and J. Waring, "Selection and amplification of uhf television signals," *Trans. I.R.E.*, PGBTR-3, pp. 5–14; June, 1953.
(1088) E. M. Hinsdale and I. D. Baumel, "A capacitive tuned uhf television tuner," *RCA Rev.*, vol. 14; December, 1953.
(1089) R. J. Lindeman and C. E. Dean, "Tuner for complete uhf-tv

coverage without moving contacts," Proc. I.R.E., vol. 41, pp. 67–72; January, 1953.

(1090) T. Murakami, "A vhf-uhf television turret tuner," *RCA Rec.*, vol. 14, pp. 318–340; September, 1953.

(1091) E. H. Boden, "Factors affecting the design of vhf-uhf tuners," *Sylvania Technologist*, vol. 6, pp. 64–67; July, 1953.

(1092) H. Fogel and S. Napolin, "Cavity tuner for uhf television," *Electronics*, vol. 26, pp. 101–103; February, 1953.

(1093) A. Newton, "Analysis of uhf tuner design," *Electronics*, vol. 26, pp. 106–111; March, 1953.

Transistors

The commercial potentialities of transistors were illustrated by the development of experimental models of personal AM and FM receivers, automobile receivers, and television receivers utilizing these devices. The all-transistor television receiver, containing thirty-seven developmental transistors, had a total battery drain of 13 watts, 25 per cent of which was the kinescope filament power. Although much information about the application of transistors was accumulated, little was applied in commercial production.

(1094) G. C. Sziklai, R. D. Lohman and G. B. Herzog, "Study of transistor circuits for television," Proc. I.R.E., vol. 41, pp. 708–717; June, 1953.

(1095) L. E. Barton, "A transistor personal broadcast receiver." Presented at IRE/RETMA Fall Meeting; October, 1953.

(1096) J. D. Fahnestock, "Experiments illustrate transistor application," *Electronics*, vol. 26, pp. 112–113; March, 1953.

(1097) G. C. Sziklai, "Symmetrical properties of transistors and their applications," Proc. I.R.E., vol. 41, pp. 717–724; June, 1953.

(1098) R. C. Ballard, "A portable transistor FM receiver," *Tele-Tech*, vol. 12, pp. 79, 206–207; August, 1953.

Production Techniques

The trend in production techniques continued toward automatic assembly and "printed" circuits.

(1099) K. M. Lord, "Mechanized dip soldering of television receivers," *Electronics*, vol. 26, pp. 130–137; June, 1953.

(1100) R. F. Newton and L. K. Lee, "Approach to mechanized assembly of electronic equipment applicable to television receivers, Inst. Radio Engrs.—Trans. of Professional Group on Broadcast and Television Receivers, PGBTR-3, pp. 25–32; June, 1953.

(1101) G. W. A. Dummer, "Embedded and printed circuits," *Electrical Manufacturing*, vol. 51, pp. 84–92; May, 1953.

(1102) G. E. Broomhall, "Printed circuit techniques for the laboratory," *Tele-Tech.*, vol. 12, pp. 36–38, 111; July, 1953.

(1103) R. A. Gerhold, "Printed circuit assemblies," *Electrical Manufacturing*, vol. 51, pp. 106–111; March, 1953.

(1104) A. F. Murray, "Project tinkertoy—step toward the automatic factory," *Tele-Tech.*, vol. 12, pp. 70–72; Nov., 1953.

(1105) R. L. Henry and C. C. Rayburn, "Mechanized production of electronic equipment," *Electronics*, vol. 26, pp. 160–165; December, 1953.

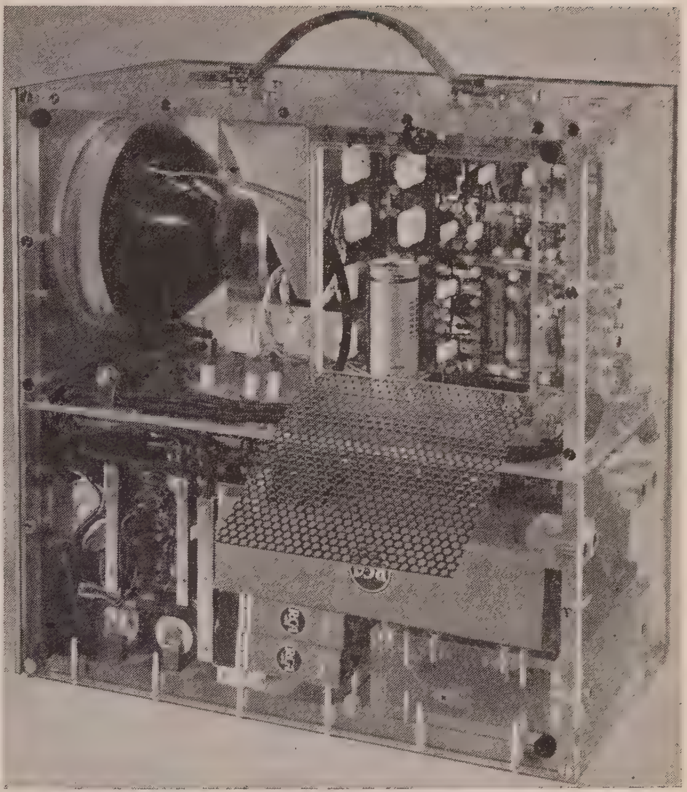
(1106) L. K. Lee and F. M. Hom, "Automatic production and electronic components," *Radio and Television News, Engineering Edition*, vol. 50, pp. 16–18; December, 1953.

Acknowledgement

The individual sections of this report were prepared by Technical Committees of the IRE, who assigned individuals or groups to carry on investigations for comprehensive review of each particular field of activity.

The Technical Committee representatives who prepared the reports are thanked for their diligence. All of the reports were reviewed by the members of the Annual Review Committee Editorial Board, and the reports were edited in style and content. Membership of the editorial Board and names of the Technical Committee members who prepared the sections of the report follow:

J. Z. Millar, *Chairman*, L. E. Whittemore, *Vice Chairman*
J. D. Crawford Shirley W. Harrison C. C. Forster
H. P. Westman



A complicated delay equalizer of 50 bridged-T, all-pass sections. It contains more than 150 precision capacitors, 100 adjustable inductors, and 100 selected resistors. (Bell Telephone Laboratories)

Antennas and Wave Guides: D. C. Ports, J. Ruze
Audio Techniques: I. M. Kerney, D. E. Maxwell
Circuits: J. T. Bangert
Electroacoustics: W. D. Goodale, Jr.
Electron Devices: R. M. Ryder, T. J. Henry, A. S. Luftman, E. O. Johnson, R. G. Stoudenheimer, G. A. Esperson, P. A. Redhead, J. Kurshan
Electronic Computer: D. R. Brown
Facsimile: J. H. Hackenberg
Feed-Back Control Systems: G. A. Biernson
Industrial Electronics: J. L. Dalke, C. F. Spitzer, H. R. Meahl
Information Theory & Modulation Systems: T. P. Cheatham, Jr.
Measurements & Instrumentation: P. S. Christaldi, W. D. George, J. L. Dalke, C. D. Owens, A. P. G. Peterson, G. L. Fredendall, R. V. Lowman, H. E. Dinger, G. A. Morton, M. J. Ackerman, J. S. Ketchell, W. J. Mayo-Wells
Mobile Communication Systems: D. Talley
Navigation Aids: P. C. Sandretto, H. C. Metz
Piezoelectric Crystals: W. P. Mason, K. S. Van Dyke
Radio Transmitters: H. Goldberg
Receivers: J. Avins
Sound Recording and Reproducing: S. M. Fairchild
Symbols: H. P. Westman
Television Systems: S. Helt
Video Techniques: J. L. Jones
Wave Propagation: M. G. Morgan, T. J. Carroll, A. C. Bemis, Martha S. Carpenter

Correspondence

Silicon *P-N* Junction Power Rectifiers and Lightning Protectors[*]

Silicon possesses a number of properties which make it of considerable interest for use in semiconducting devices. Silicon *p-n* junction rectifiers have reverse currents at least 1,000 times smaller than those of germanium. Temperature rises of at least 150 degrees C. above room temperature may be tolerated with silicon, whereas germanium and other semiconducting rectifiers are limited to about 40 degrees C. rise. At reverse voltages above breakdown silicon *p-n* junctions show remarkably flat voltage saturation characteristics, and the breakdown voltage is controllable over a range from a few volts to several hundred volts.

The above characteristics are now available in small area silicon *p-n* junction alloy devices.[1] Although the outstanding characteristics of silicon *p-n* junction devices have been understood for sometime, the inability to fabricate large area junctions as well as to make low resistance contacts to silicon surfaces has prevented the fabrication of higher power devices. The present article describes a new method for preparing large area silicon *p-n* junctions and gives the electrical characteristics of two power devices prepared by this method. Although both are still in the experimental stage, their properties seem sufficiently promising to report at this time.

Diffusion Technique: The new technique, which will be described more fully elsewhere, consists of diffusing donor (e.g. phosphorus) or acceptor (e.g. boron) impurities into high purity single crystal silicon[2] surfaces at temperatures above 1000 degrees C. Planar layers of controllable thicknesses up to a few mils may be produced in this manner, and the area is limited only by the size of the silicon ingot. The barriers prepared in this way not only possess excellent reverse current and voltage saturation properties, but also the resistivities of the diffused layers are as low as 0.001 ohm cm. This low resistivity surface layer permits the direct application of metallized contacts thus solving in a simple manner the difficult problems of making contact to silicon. The technique described above has already been utilized to produce a highly efficient silicon photocell for the conversion of solar radiation into electrical power.[3]

Power Rectifiers: Semiconducting power rectifiers currently in use are fabricated mainly from copper oxide, selenium, and germanium. The first two of these materials are limited to fairly low reverse voltages and none of them operates satisfactorily at temperatures above 70 degrees C. Fig. 1(a) indicates the configuration of a completed silicon single-cell *p-n* junction rectifier. Acceptor impurities are diffused into one side of an *n*-type silicon slab to form the *p-n* junction and the low resistivity *p*-type layer. Donor impurities are diffused into the opposite side to form a low resistivity *n*-type surface layer. Both sides are then metallized and the unit is pressed between metal electrodes. Fig. 2 is a plot of the static current versus voltage characteristics of such a unit having an area of approximately 0.75 cm². Curves are given for continuous operation at ambient temperatures of 27 degrees C., 100 degrees C., and 150 degrees C. Forward currents up to 20 amperes were obtained with an over-all forward resistance of .08 ohms. As a power rectifier operating into a resistance load the efficiency is somewhat better than 95 per cent. Because of the small reverse currents, the loss comes almost entirely in the forward direction. Although the maximum reverse voltage of this unit is about 85 volts, this may be varied through a choice of the silicon ingot resistivity.

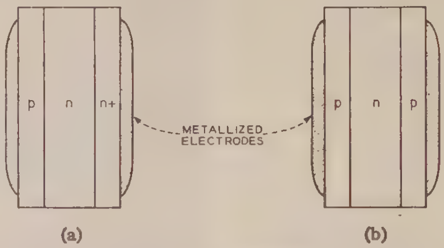


Fig. 1—Configurations of large area silicon *p-n* junction power devices; a. power rectifier, b. lightning protector.

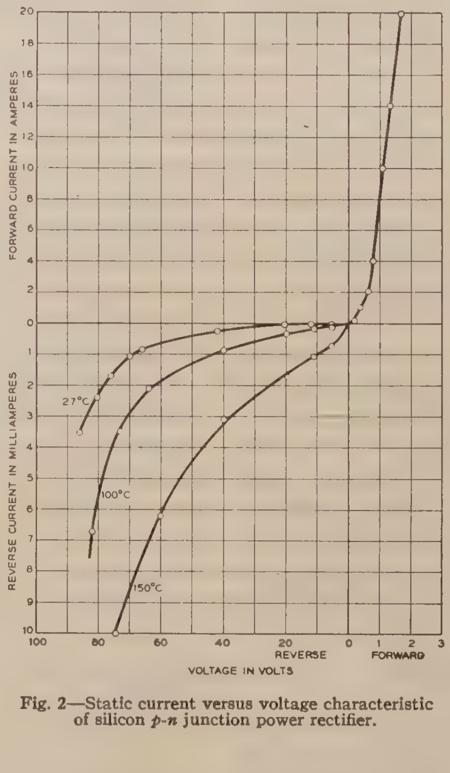
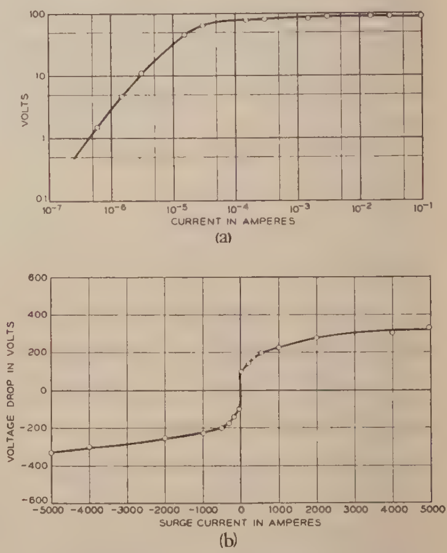


Fig. 2—Static current versus voltage characteristic of silicon *p-n* junction power rectifier.

Lightning Protectors: Lightning protectors dissipate the energy of high voltage surges but allow equipment which they are protecting to function normally under ordinary operating conditions. A large area silicon *p-n-p* junction as shown in Fig. 1(b) is ideal for this purpose. It has a high resistance at all voltages below breakdown, but under high current surges the voltage rise is limited. The protector is equally effective for surges of either polarity and will dissipate the energy of high amperage pulses of short duration such as those present in lightning surges. The protector is made by diffusing acceptor impurities into both sides of an *n*-type silicon slab thus forming two opposing *p-n* junctions. The electrical characteristics of such a protector are shown in Fig. 3. Although the saturation voltage of the unit shown here is 95 volts, this value has been varied from 30 to 200 volts through a choice of the silicon-ingot resistivity. Fig. 3(a) gives the static current voltage characteristic at low currents and Fig. 3(b) the voltage limiting characteristic in the saturation range for 20 microsecond duration current pulses as high as 5,000 amperes. The voltage rise at high currents is due mainly to the resistance of the *n*-type layer which amounts to 0.05 ohms in this unit.



(a)

(b)

Fig. 3—Electrical characteristics of *p-n* junction lightning protector; a. high resistance range, b. voltage saturation range. (We are indebted to A. E. Dietz for assistance in obtaining these data.)

Conclusion: Although the silicon *p-n* junction devices described in this paper are still in the experimental stage, they show promise of contributing greatly to the technology of power rectification and lightning protection.

G. L. Pearson and C. S. Fuller
Bell Telephone Labs.,
Murray Hill, N. J.

---

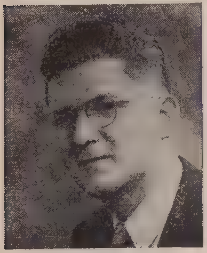
[*] Received by the Institute, March 5, 1954.

[1] G. L. Pearson and B. Sawyer, "Silicon *p-n* junction alloy diodes," Proc. I.R.E., vol. 40, pp. 1348–1351; November, 1952.

[2] G. K. Teal and E. Buehler, "Growth of silicon single crystals and of single crystal silicon *p-n* junctions," *Phys. Rev.*, vol. 87, p. 190; July, 1952.

[3] D. M. Chapin, C. S. Fuller, and G. L. Pearson, "A new silicon *p-n* junction photocell for converting solar radiation into electrical power," *Jour. Appl. Phys.* (In press). Presented orally by D. M. Chapin at AIMME annual meeting, New York, N. Y., February 15, 1954.

Contributors



G. E. Boggs

G. E. Boggs (M'52) was born in Chicago, Illinois, on April 22, 1921. He attended the Illinois Institute of Technology in 1942, and later attended George Washington University from which he was graduated with the degree of B.E.E. in 1948. In 1952 he received the M.S. degree in electrical engineering from the University of Maryland.

From 1941 to 1942, Mr. Boggs was employed by the Belmont Radio Corporation of Chicago. He entered the Armed Forces in 1943, and was subsequently assigned to the Communications Laboratory of the Office of Strategic Services in 1944, where he served as a design engineer on military communications equipment until the end of 1945.

Since 1948, he has been employed by the National Bureau of Standards in the Experimental Ionospheric Research Section of CRPL in Washington, D.C. During this period he has been working on RF instrumentation and gain stability problems encountered in field intensity recording.

❖

A. N. Goldsmith

Alfred N. Goldsmith (M'12–F'15–L'54) received the B.S. degree from the College of the City of New York in 1907, the Ph.D. degree from Columbia University in 1911, and the Sc.D. (Honorary) degree from Lawrence College in 1935.

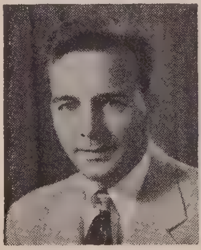
A co-founder, Fellow, and Life Member of the Institute, Dr. Goldsmith has served as Editor every year but one, President for one term, Secretary for ten years, and has been a Director of the IRE continuously since its inception in 1912. In recognition of his distinguished service he has been appointed Editor Emeritus as of January 1, 1954.

Dr. Goldsmith is noted equally for his many technical contributions to the radio, phonograph, television, color television, and motion picture fields. He has been associated with the College of the City of New York since 1906 where he is associated professor of electrical engineering with life tenure. He has served as consulting engineer for the General Electric Company, 1915–1917; Director of Research, Marconi Wireless Telegraph Company of America, 1917–1919; held the positions of Director of Research, Chief Broadcast Engineer, and Vice President of RCA during the period 1919–1933; and is now a private consulting engineer.

Dr. Goldsmith is the only holder of both of the highest IRE awards, the Founders Award, which was presented during the 1954 IRE National Convention, and the Medal of Honor. Among other honors he has received are the Modern Pioneer Award from the National Association of Manufacturers, the Townsend Harris Medal from the College of the City of New York, the Medal Award of the Television Broadcasters Association, and the Radio Pioneers Special Citation.

He holds membership in numerous engineering and scientific societies and is a past president of the Society of Motion Picture and Television Engineers, and is chairman of the Board of the National Television Film Council.

❖



A. A. Hauser

A. A. Hauser, Jr. (M'48) was born in Dayton, Ohio on January 28, 1920. He received the B.S. degree in mathematics from the Massachusetts Institute of Technology in 1942, the M.S. degree in mathematics from New York University in 1950, and has since been studying for his Doctorate in electrical engineering at Columbia University.

In 1942 Mr. Hauser joined the Sperry Gyroscope Company, and remained there until 1946, when he accepted a teaching position at the Rensselaer Polytechnic Institute. He returned to Sperry Gyroscope in 1948, where he has undertaken work in the fields of analog computers, digital computers, and system synthesis. At the present time, he is Engineering Department Head for Special Armament Systems.

Mr. Hauser is now the chairman of the advisory council for mathematics, and is also an associate trustee, at Adelphi College, Garden City, N. Y.

❖

E. Keonjian (M'50–SM'52) was born in Tiflis, Caucasus, Russia, on August 14, 1909. He attended the Leningrad Institute of Electrical Engineering and received the M.S. degree in electrical engineering from there in 1932.

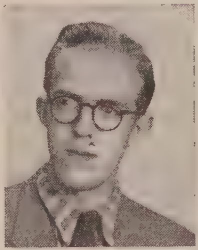
After graduation he joined the Leningrad Central Radio-laboratory as a research engineer, and in 1935 was transferred to the Leningrad Research Institute of Electro-Physics as a senior engineer. During the time from 1939 to 1940 he was engaged in the project and development work for Naval Radio Communication. In 1940 Mr. Keonjian returned to the Leningrad Institute of Electrical Engineering as an instructor in electrical communications and electronics courses.

E. Keonjian

After spending five years in Germany, Mr. Keonjian came to the United States, joining Westinghouse Electric Corporation, Jersey City, N. J., in 1947. In 1949 he was appointed as a lecturer in electronics and electrical communication at the City College of New York. In 1951 he joined the Engineering staff of General Electric Company, where he is engaged in the development work concerned with transistors and advanced electronics circuitry.

Mr. Keonjian is a member of the General Electric Engineers Association, holds a professional engineering license in the state of New York, and is a co-author of the book, "Principles of Transistor Circuits," edited by R. F. Shea, recently published by John Wiley and Sons, New York, N. Y. in 1953.

❖



H. L. Knudsen

H. Lottrop Knudsen was born in Holstebro, Denmark, on December 8, 1917. He received the M.S. degree in telecommunication engineering from The Royal Technical University of Denmark in Copenhagen in 1942. Immediately following graduation he worked as an assistant in teletechnics and the electromagnetic theory at Chalmers Technical University, Gothenburg, Sweden. From 1943 to 1946, he was engaged as an engineer at the Sieverts Kabelverk in Sundbyberg, Sweden, where he worked on problems concerning power cables, especially their heating, induced voltages therein, and oil flow in oil-filled cables. In the latter year he substituted for the professor in electromagnetic theory at Chalmers Technical University.

From 1946 to 1947, Mr. Knudsen was a student of applied physics at Harvard University, receiving the M.S. degree. In 1948 he returned to Denmark to take up teaching duties at the Royal Technical University. He has been concerned principally with the waveguide theory, antenna theory, and other branches of applied mathematics. He has published papers on these subjects and a textbook on electromagnetic theory.

In 1953 Mr. Knudsen was awarded the Danish Esso-prize for his work in the technical sciences, and in the same year he received a Dr. Tech. degree from the Royal Technical University in Copenhagen.

Contributors

G. Kron was born in Nagybanya, Hungary on July 23, 1901. He graduated from the University of Michigan in 1924. After graduation, he spent several years traveling around the world. Most of his earlier technical jobs were connected with the electrical power industry; he has been associated with the Lincoln Elec. Co. and the Westinghouse Co. Mr. Kron joined General Electric Co. in 1934 as a designer and consulting engineer. He later expanded into electronics and nuclear engineering. He has been concerned with extending the useful range of digital computers into the realm of large engineering systems thought to be unmanageable by existing computers.

G. KRON

He is a member of the Amer. Physical Society and A.I.E.E.

G. Smiley was born on June 10, 1904, in Niles, Ohio. He studied Electrical Communications at the Massachusetts Institute of Technology for three and one-half years. He left college during the middle of his senior year to work in the engineering department of the Samson Electric Co. in Canton, Mass; he later became Chief Engineer there. Mr. Smiley also served as Chief Engineer at the S. H. Couch Co. in North Quincy, Mass. and the General Control Co. in Cambridge, Mass. He is now Senior Engineer for the General Radio Co., Cambridge, Mass., and Director of the S. H. Couch Co.

GILBERT SMILEY

Mr. Smiley holds patents in the field of audio frequency amplification, electronic musical instruments, and control devices.

D. K. Weaver, Jr. (S'48–A'51) was born in Great Falls, Montana on July 18, 1924. He attended Stanford University, receiving the B.S. degree in 1948. In 1949 he received the M.S. degree there, and in 1950 received the Electrical Engineering degree. From 1942 to 1946 he was a radio technician with the United States Army.

D. K. WEAVER, JR.

Mr. Weaver was employed as a research assistant in the department of electrical engineering at Stanford University, during the time he was taking graduate work there. He joined the staff of the Stanford Research Institute, as a research engineer, in September of 1950.

He is a member of Tau Beta Pi and Sigma Xi.

IRE News and Radio Notes

1954 NEREM TO BE HELD IN MAY

The North Atlantic Region of the IRE will sponsor the biggest New England Radio Engineering Meeting on record, to be held at the Sheraton Plaza Hotel, Boston, Mass., from May 7–8.

The highlights of the technical sessions will be: "Transistors, Their Present Applications and Further Development," Dr. Harry L. Owens, Signal Corps Engineering Laboratories; "The Study of Noise Generation in Oscillators," Dr. Winston M. Gottschalk, Raytheon Manufacturing Co.; "Developments in Stereophonic Sound," Robert Paulson, Ampex Corporation; "Tinkertoy Techniques for Mass Producing Electronic Circuits," James D. LeVan, Sanders Associates; "Continuous Electronic Measurement of Physiological Variables in the Operating Room," Drs. Herbert P. Broida and Saul R. Gilford, National Bureau of Standards; and "Color Television, Its Challenge to the Engineer," Donald G. Fink, Philco Corporation. In addition to these distinguished speakers, other leaders in the electronic field are being selected to complete an inspiring program.

The chairmen of the three technical sessions will be R. Dudley, Boston Section, Eric Vaughan, Conn. Valley Section, and L. E. Packard, North Atlantic Region.

The latest developments in electronic equipment and components will be displayed by some one hundred companies and representatives. Their exhibits will be open for both days of the meeting.

A TRIBUTE TO ALFRED N. GOLDSMITH, EDITOR EMERITUS

The following is the text of a scroll presented to Dr. Alfred N. Goldsmith during the IRE Annual Banquet, Waldorf-Astoria Hotel, New York City, March 23, 1954.

The Institute of Radio Engineers, Inc.

Be it known that, by these Presents, as ordered by its Board of Directors, The Institute of Radio Engineers bestows this testimonial of esteem and respect upon Alfred Norton Goldsmith on the occasion of his appointment as Editor Emeritus.

As a Founder, Secretary for many years, Past President, recipient of the Medal of Honor, unbroken service as a Director, and the Editor of its Publications for more than forty years, he has, by unstinting devotion, wise counsel, and continuous personal guidance of its editorial policies, contributed eminently to the sound and solvent growth of The Institute of Radio Engineers. This leadership and dedication of his efforts stand as inspirations for those others who must carry on these tasks.

WILLIAM R. HEWLETT, *President*
HARADEN PRATT, *Secretary*

NEW SUBSECTIONS APPROVED

At the January 5th meeting of the IRE Executive Committee, the formation of two new subsections was unanimously approved.

The new subsections are the Berkshire County Subsection of the Connecticut Valley Section, which will include the territory of Berkshire County, Mass., and the Tucson Subsection of the Phoenix Section, which will include Cochise, Graham, Greenlee, Pima, and Santa Cruz counties.

CUMULATIVE INDEX AVAILABLE

The Cumulative Index for the PROCEEDINGS OF THE I.R.E., TRANSACTIONS OF THE I.R.E. PROFESSIONAL GROUPS, and the CONVENTION RECORD OF THE I.R.E., for the period 1948–1953, will soon be available. The Index will be sold to members at a price of $1.00, and to nonmembers at a price of $3.00. Orders with payments should be sent to The Institute of Radio Engineers, 1 East 79 Street, New York 21, N. Y.

IRE News and Radio Notes

Calendar of COMING EVENTS

Stanford Research Institute-United State Air Force Symposium on Automatic Production of Electronic Equipment, Fairmont Hotel, San Francisco, Calif., April 19–20

IRE-IAS-RTCA Symposium, "Potentialities of the Next Fifty Years in Aviation," Franklin Institute, Philadelphia, Pa., April 22–24

IRE-AIEE Special Technical Conference and Symposium on Military Communication, Western Union Auditorium, New York, N. Y., April 28

Electrochemical Society Semiconductor Symposium, La Salle Hotel, Chicago, Ill., May 2–6

IRE-URSI Spring Meeting, National Bureau of Standards, Washington, D. C., May 3–6

Society of Motion Picture & TV Engineers, 75th Semi-Annual Convention, Hotel Statler, Washington, D. C., May 2–7

IRE-AIEE-RETMA Electronic Components Symposium, Washington, D. C., May 4–6

IRE Seventh Region Technical Conference, Multnomah Hotel, Portland, Ore., May 5–7

IRE New England Radio Engineers ing Meeting (NEREM), Sheraton Plaza Hotel, Boston, Mass., May 7–8

IRE National Airborne Electronic Conference, Biltmore Hotel, Dayton, Ohio, May 10–12

IRE-AIEE-IAS-ISA National Telemetering Conference, Morrison Hotel, Chicago, Ill., May 24–26

IAS Annual Summer Meeting, IAS Building, Los Angeles, Calif., June 21–24

IRE Symposium on Global Communications, Washington, D. C., June 23–25

British Institute of Radio Engineers, 1954 Convention, Christ Church, Oxford, England, July 8–12

IRE Western Electronics Show and Convention, Pan Pacific Auditorium, Los Angeles, Calif., August 25–27

National Electronics Conference, Sherman Hotel, Chicago, Ill., October 4–6

IRE-RETMA Radio Fall Meeting, Hotel Syracuse, Syracuse, N. Y., October 18–20

IRE Quality Control Symposium, Statler Hotel, New York, N. Y., November 12–13

National Conference on Airborne Electronics to Be Held in May

The National Conference on Airborne Electronics, co-sponsored by the Dayton Section of the IRE and the IRE Professional Group on Aeronautical and Navigational Electronics, will be held May 10–12 at the Dayton-Biltmore Hotel, Dayton, Ohio.

R. J. Doran, President of the Airborne Electronics Conference, who will give the welcoming address.

The Conference, entitled "Electronics: Key to Air Supremacy," will offer 80 technical papers and 60 exhibits dealing with the latest developments in Airborne Electronics and related interests. Mr. R. J. Doran, President of the Conference, will deliver the welcoming address to the group.

A subject of vital interest to all those who attend will be a forum, "In the Challenge of the Jet Age, How Complex Can Military Equipment Get and Still Be Practicable, Maintainable, and Tactically Effective?" The Moderator for this forum will be Dr. W. R. G. Baker of the General Electric Co. Speaking for the Equipment Manufacturers will be Fred Henderson, Western Electric Co.; A. F. Van Dyck, RCA; J. F. Byrne, Motorola, Inc.; E. K. Foster, Bendix Aviation Corp.; and C. F. Draper, Massachusetts Institute of Technology. Representing the Equipment Users will be Major General C. S. Irvine, Air Material Command; Major General G. S. Blake, Airways and Air Communications Service; J. E. Keto, Wright Air Development Center, H. C. Rempt, Lockheed Aircraft Corp.; and T. H. McNary, Boeing Airplane Co.

Advance registration fee for members is $1.50; registration at Conference, $2.50. Nonmember advance registration, $2.50, and at Conference, $3.50. For further information, or to register, write J. Paul Georgi, Registration Chairman, 410 West First Street, Dayton 2, Ohio.

Intensive Courses in Automatic Control Offered

The University of Michigan, College of Engineering, has announced two Intensive Courses in Automatic Control. The first is scheduled for June 14 to 19 inclusive, and the second for June 21 to 23 inclusive. The courses are intended for engineers who find it necessary or who wish to obtain a basic understanding of the field, but who cannot spare more than a few days for this purpose. The aim of the courses is to make it easier to learn by a coherent presentation of the fundamentals of modern automatic control and by providing a comprehensive set of notes to serve as a framework for further study.

The courses are built around the principles and application of measurement, communication, and control. Course I will consist of the fundamentals in each of these fields, and will include some fundamental work in nonlinear systems. Course II will take up applications of the fundamentals to more advanced problems. There will be four hours of lecture each morning and three hours of demonstration in the afternoon. Extensive use will be made of computing, instrumentation, and servo laboratories on the campus, made available by the Aeronautical and Electrical Engineering Departments. The role of analog computing methods will be emphasized.

April 15 is the closing date for registration. Further information may be obtained by writing to Professor M. H. Nichols, Room 1523, East Engineering Building, University of Michigan, Ann Arbor, Mich.

Technical Writers' Institute Planned

The second annual Technical Writers' Institute will be held at Rensselaer Polytechnic Institute, Troy, N. Y., beginning Monday, June 21 through Friday, June 25. The Writers' Institute is designed for supervisors of technical writing in business and industry, educational programs and promotional work, and gives instruction and refresher work in all phases of technical writing.

Included in the course of study and discussions are sessions on operational manuals, reports, direct business communications, company-public relations, and associated fields. The week is devoted to group discussions, lectures by outstanding authorities, personal consultations, and writing-practice exercises. A group of eight from the Rensselaer faculty conducts the course under the guidance of Dr. S. P. Olmsted, head of the English department, and Jay R. Gould, director of the Technical Writers' Institute.

New Chapters Approved

At the March 2nd meeting of the Executive Committee the following Professional Group Chapters were approved: The Connecticut Valley Chapters of the Professional Group on Nuclear Science, and the Professional Group on Medical Electronics.

IRE News and Radio Notes

Reviewing Papers for the Proceedings of the I.R.E.

> The following is a reprint of instructions to reviewers of Proceedings papers. It is reprinted here in the belief that it will be of interest not only to prospective authors but to the general membership as well.
>
> —*The Editor*

Technical papers submitted for publication in the Proceedings of the I.R.E. are sent simultaneously to three reviewers. The decision whether or not to publish is based on the comments of these reviewers. The Proceedings cannot be a good journal without their frank, wholehearted assistance. The reviewer himself must have some guidance if he is to do a good job.

A reviewer is chosen as an expert in the field of the paper. If he does not feel competent to review it adequately, he should either give it to someone he trusts for review, or he should return it quickly.

If he does feel competent to review it, he should get it back within two weeks. In fairness to people whose work deserves early, prompt publication, we must have prompt reviews.

A reviewer should report any detailed mistakes or errors in complicated mathematical proofs or in computations which he finds. However, it is primarily the author's responsibility that the paper be correct in detail, and the reviewer should feel safe in recommending a paper if the basic premises, the method of attack, and the conclusions drawn, appear to be reasonable to him as an expert, even if he has not followed each mathematical step in detail. If the reviewer is puzzled or doubtful, he should say so.

Not all technically sound papers are suitable for the Proceedings.

A suitable paper may describe an advance in the field, a new system, a new invention, a new measurement, a new theory, or a new method of calculation. The advance should be important enough so that the paper will be of general interest.

Papers which do represent good, sound, important work, but which will be of interest to a few specialists only, may be more suitable for publication in the Transactions of one or another of the Professional Groups. Papers may be more suitable for publication in some entirely different journal. It is no reflection on the paper if the reviewer recommends such an alternative.

A paper must represent a sound and important technical contribution. It is desirable that it have other virtues as well.

The author should state clearly at the beginning what he has accomplished and why it is important, and he should state this in plain English. This is particularly valuable in the case of papers which are highly mathematical.

If the author presents important curves or equations, he should try to state clearly what they mean and how to use them, so that the reader doesn't have to dig through the whole text if he wants to use them.

The paper should not contain old material or previously published material unless this seems for some reason absolutely essential.

In the end, the reviewer is faced with the problem of filling out a review form. He is asked to answer certain specific questions. He is asked to make specific recommendations: the paper should be rejected outright; it should be submitted to the appropriate Transactions or some other named journal; or it should be published in the Proceedings either unaltered, or cut, lengthened, or otherwise changed according to the reviewer's recommendations.

It is equally important that the reviewer tell in his own words, under the heading "Evaluation" just what he thinks of the paper, for this will be very helpful in comparing the reviews and in reaching a final decision.

Technical Committee Notes

On January 14th the Standards Committee convened under M. W. Baldwin, Jr. in the absence of the Chairman, A. G. Jensen. Comments on the ASA C42 Television Definitions had been received prior to the meeting, and appropriate action on them was suggested to the assembly. There was a discussion of the Proposed Standards on Electron Devices: Definitions of Terms Related to Phototubes. Minor changes were incorporated in this standard. The term Equivalent Noise Input was deleted from it. Paragraph three of P. J. Herbst's letter to L. G. Cumming was read to the committee. General agreement was that closer co-operation between the Mobile Communications Committee, Radio Transmitters Committee, and the Navigation Aids Committee should be encouraged. An ad hoc committee was appointed, composed of Messrs. Budelman, Sandretto, Herbst and Avins. The recommendations of this committee will be brought before the Standards Committee in the very near future.

On February 11th, the Committee gave final approval to Standard 53 IRE 3. S1 of the Audio Techniques Committee. An ad hoc committee was appointed to study a proposed new unit for logarithmic ratios as suggested by E. I. Green. Jack Avins is Chairman and M. W. Baldwin, Jr. and Robert Serrell members. Revised technical committee scopes were reviewed and will be adopted shortly.

Under the chairmanship of C. A. Cady the Audio Techniques Committee convened on December 1st. The Committee reviewed the proposed "Introduction" to the Definitions of Audio Terms (53 IRE 3. S1). A number of changes were made and approval was given by the Committee. The Introduction is now ready for Standards Committee action. There was a review of Subcommittee activities. Mr. Cady advised the Committee that because of other activities Mr. Black will be forced to retire as Chairman of Subcommittee 3.2. The Committee next discussed the Proposed Standard 53 IRE 19.1 PS4 and 25.4 PS3 on Intermodulation Distortion. The work is at subcommittee level and it was agreed that the Committee should wait until it reaches main committee level before commenting. Discussion of ASA C42 Definitions was turned over to Mr. Augustadt who had discussed them at the Standards Committee meeting held on November 12th.

On January 14th the Feedback Control Systems Committee met under the chairmanship of J. E. Ward. Chairman Ward initialed further discussion of the use of a summing point in the Basic Feedback Loop to help clarify for Subcommittee 26.1 the action on this point by the Committee at a previous meeting. Messrs. Lozier and Aaron of the subcommittee were present to discuss the subcommittee's objections to the use of a summing point in the Basic Feedback Control Loop. Mr. Lozier pointed out two specific Feedback Control Systems which were displayed in block diagram form without the use of a summing point. He felt that since these two systems were not described using a summing point, and since there might also be other systems in this category, it would be too restrictive to define the basic loop with a summing point. A discussion in favor of the use of a summing point was presented by G. A. Biernson. There was considerable discussion as to whether the summing point is not a requirement in a feedback control system. Professor Linvill stated that he feels the process of comparison is inherent in feedback control. The members of the Committee agreed to investigate this philosophy of feedback control systems pointed out by Professor Linvill with the objective of determining, if possible, a system which violates the premise that a comparison is inherent to any feedback control system. It was further decided to consider incorporating the requirement of comparison in the definition of a feedback control system.

The Sound Recording and Reproducing Committee convened on January 29th under the chairmanship of A. W. Friend. In the absence of A. P. G. Peterson, Chairman of Subcommittee 19.1 on Magnetic Recording and Reproducing, M. S. Corrington presented his re-written version of Note 2 of the "Proposed Standards on Intermodulation Distortion: Definitions and Procedures for Measurement," dated November 16, 1953. Lincoln Thompson, Chairman of Subcommittee 19.2 on Mechanical Recording reported that progress is being made in his subcommittee in relation to the work on "Disk Frequency Records." Mr. Fraser, Chairman of Subcommittee 19.3 on Optical Recording and Reproducing intends to mail progress data to the Chairman. Mr. Roys reported for the CCIR Task Group 19.4. The Committee considered the suggestions made at the January 14th meeting of the Standards Committee to obtain uniform style in the Technical Committee scopes. Recommendations were made by the Committee to change the name and scope. These will be presented to the Standards Committee at its next meeting.

IRE News and Radio Notes

1954 National Telemetering and Remote Control Conference

SPONSORED BY IRE, IAS, ISA, AND AIEE
MORRISON HOTEL, CHICAGO, ILLINOIS—MAY 24–26

Monday, 9:30 A.M., May 24

TELEMETERING SYSTEMS

F. P. Lehan, *presiding*

"Flutter Characteristics Study Using Telemetered Free Flight Aircraft Models," C. L. Wetzel, Pacific Div., Bendix Aviation Corp.

"A Large Research and Development FM/FM Telemetering System for Extreme Environmental Conditions," A. W. Newberry, California Institute of Technology

"A Transistorized FM/FM Telemetering System," R. E. Colander and C. M. Kortman, Pacific Div., Bendix Aviation Corp.

"Selective Telemetering Application," L. G. Walker, Motorola, Inc.

"Telemetering of the Illinois-Missouri Electric Power Pool," G. W. Fox, Union Electric Co., D. F. Hazen, Illinois Power Co., H. E. Stites, Central Ill. Public Service Co., W. S. Bloor and T. W. Hissey, Leeds and Northrup Co.

"Recorder Computing Techniques Used in the Measurement of Electric Power and Associated Quantities," W. E. Phillips, Leeds and Northrup Co.

2:00 P.M.

TELEMETERING PICKUPS AND COMPONENTS

James Wynn, *presiding*

"Application of Transistors to Telemetering Components," C. M. Kortman, Pacific Div., Bendix Aviation Corp.

"A New Sub-Carrier Oscillator," E. L. Tarca, Ralph M. Parsons Co.

"A New Panoramic Instrument for Analyzing and Calibrating FM/FM Telemetering Systems," W. I. L. Wu, Panoramic Radio Products, Inc.

"New High Stability Component Configurations Solve Telemetering Systems Design Problems," L. A. G. ter Veen, Pacific Div., Bendix Aviation Corp.

"Movable Core Transformers as a Pickup for Industrial Telemetering Systems," A. J. Hornfeck, Bailey Meter Co.

8:00 P.M.

WORKSHOP SESSION

W. J. Mayo-Wells, *presiding*

General Discussion Paper: "Classification of Telemetering Systems," W. J. Mayo-Well and E. Lynch, General Electric Co.

Tuesday, 9:30 A.M., May 25

REMOTE CONTROL—DIGITAL

Perry Crawford, Jr., *presiding*

"An electronic System for Air Traffic Control Information," R. M. Kalb, Engineering Research Associates

"Remote Shaft Positioning Via Frequency Code Data Transmission Systems," H. B. Shultheis, Pacific Div., Bendix Aviation Corp.

"Some Fundamental Limitations and Capabilities of Sampled Data Systems," W. K. Linvill, Massachusetts Institute of Technology

"A Proposed Air Traffic Control System," B. Gordon, Laboratory for Electronics

2:00 P.M.

REMOTE CONTROL—ANALOG

G. R. Barton, *presiding*

"Application of Analog Computers to Sampling Control Systems," H. Meissenger and A. Karen, Reeves Instrument Co.

"Automatic Helicopter Positioning Through Present and Future Gyro Pilot Control," J. Grano, Sperry Gyroscope Co.

"Application of Raydist to Remote Helicopter Control," J. T. Bradbury and A. Comstock, Hastings Instrument Co.

"Design of High Performance Hydraulic Control System," M. Feder and K. Bailey, Bendix Aviation Corp.

"A Damper Stabilized Servo Data Repeater," J. E. Ward, Massachusetts Institute of Technology

7:30 P.M.

ANNUAL BANQUET

Everett S. Lee, *speaker*

Wednesday, 9:30 A.M., May 26

ALL WEATHER FLIGHT CONTROL

D. S. Little, *presiding*

(The Program, not yet finalized, will include various problems and plans associated with the all weather flight problem. Papers will be presented by various civilian and military experts in this field.)

12:45 P.M.

LUNCHEON

"Telemetering and Remote Control, Future Applications," C. H. Hoeppner, *speaker*

2:30 P.M.

INFORMATION HANDLING—DATA REDUCTION

B. S. Benson, *presiding*

"Problems in Telemetry Data Reduction," D. Belloff, Telecomputing Corp.

"Cost Reduction in Data Reduction," D. B. Prell, Benson-Lehner Corp.

"A System for Recording and Reducing Airplane Flight Data," R. E. Colander and D. Evans, Pacific Div., Bendix Aviation Corp.

"A New Instrumentation Tape Recorder," C. C. Shaw, Bing Crosby Enterprises, Inc.

"A New Data Reduction Facility for PWM-FM Telemetry," F. Bryant, Douglas Aircraft Co., Inc.

Professional Group News

MILITARY COMMUNICATION SYMPOSIUM SCHEDULED

The IRE Professional Group on Communications Systems, and the AIEE Communication Division are jointly sponsoring a Special Technical Conference and Symposium on Military Communication, to be held on April 28, 1954, at the Western Union Auditorium, 60 Hudson Street, New York, N. Y.

Papers will be presented by engineers from the Coles Signal Laboratories, Fort Monmouth, N. J.; Bell Telephone Laboratories, Murray Hill, N. J.; and Western Union Telegraph Co., New York, N. Y. Three subjects will be covered: the ANTRC-24 radio relay, the TCC carrier telephone, and the FGC-29 multi-channel carrier telegraph equipment. ANTRC-24 and TCC equipment will be available for inspection.

Advance registration by mail will be accepted until Wednesday, April 21, 1954. Tickets will be mailed if the application is received in time; otherwise they will be held at the registration desk. Since registration facilities are limited, advance registration is requested when possible.

The fee for IRE-AIEE members is $2.00; for nonmembers, $4.00. Mail applications with check or money order in the name of the Institute of Radio Engineers, Inc., to the following: Mr. J. L. Callhan, Radio Corporation of America, the RCA Laboratories Division, 66 Broad Street, New York 4, New York.

Professional Group News

New Chapters Approved

Three new Chapters were approved by the I.R.E. Executive Committee at the February 2nd meeting. They are the Seattle Chapter of the Professional Group on Circuit Theory, the Philadelphia Chapter of the Professional Group on Component Parts, and the Washington, D. C. Chapter of the Professional Group on Component Parts.

URSI Spring Meeting

The USA National Committee of the International Scientific Radio Union (URSI) and the IRE Professional Groups on Antennas and Propagation and Microwave Theory and Techniques are jointly sponsoring a meeting consisting of technical sessions on May 3–6 at the National Bureau of Standards, Washington, D. C. A combined technical session of interest to all participants is scheduled for the morning of May 4, to be followed by one or more sessions in each of the following fields of radio science: radio measurement methods and standards; tropospheric radio propagation; ionosphere radio propagation; terrestrial radio noise; radio astronomy; radio waves and circuits, including general theory and antennas; and electronics. A Symposium on Millimeter Waves planned by the PGMTT and URSI Commission 6, will be a feature of the meeting.

The complete program will be announced shortly. Additional details and advance registration will be available through the Secretary of the USA National Committee, W. E. Gordon, School of Electrical Engineering, Cornell University, Ithaca, N. Y.

Radio Meteorology Proceedings Available

The complete Proceedings of the Conference on Radio Meteorology, cosponsored by the Professional Group on Antennas and Propagation, and held at the University of Texas, Austin, Tex., on November 9–12, 1953, are now available. These publications, entitled "Proceedings of the Conference on Radio Meteorology," and "Supplement to the Proceedings of the Conference on Radio Meteorology," may be obtained from the Bureau of Engineering Research of the University of Texas for $3.00 and $2.00, respectively, per copy.

The first of these volumes includes summaries of about 48 of the 66 papers presented at the Conference. The second volume includes summaries of the remaining 17 papers, as well as discussion summaries, corrections and additions to earlier papers, a publication record of the Third Radar Weather Conference Papers, and a list of registrants.

The papers included in these Proceedings cover such topics as tropospheric propagation, refractive index meteorology, atmospheric scattering and turbulence, thunderstorm and tornado atmospherics, cloud and precipitation physics, and operational uses of weather radar.

IRE People

T. C. Rives

Brigadier General Tom C. Rives (SM'48–F'54) has recently been appointed manager of the new Laboratories Department of the Electronics Division of the General Electric Co. He joined General Electric at Syracuse in 1950, where he was manager of Technical Military Liaison at the time of his new appointment.

A native of Montgomery, Ala., General Rives graduated from Alabama Polytechnic Institute in 1916. He earned the professional degree of electrical engineer at that institution in 1917, and received his Master's degree from Yale University in 1927.

In 1949, he retired from military duty, after more than 31 years' service. During World War II he served as chief of several divisions in the office of the Chief Signal Officer, and a Deputy Air Communications Officer for the Army Air Force. He served from 1945 to 1949 as chief of the electronics sub-division in the Air Material Command at Wright-Patterson Air Force Base. Upon his retirement in 1949, he joined the University of Illinois as a special research associate professor.

General Rives holds the Legion of Merit, the Distinguished Service Medal, and the award of Honorary Commander of the Order of the British Empire. He is a member of the Research Scientists of America and Sigma Xi.

The appointment of **Thomas T. Goldsmith, Jr.** (A'38–SM'46–F'49), and **C. Edwin Williams** (M'52), as Vice-President in Charge of Research and Vice-President in Charge of Instruments and Transmitters, respectively, has been recently announced by the Board of Directors of the Allen B. Du Mont Laboratories, Inc.

Dr. Goldsmith, who is one of the outstanding electronics and television scientists, is a member of Du Mont Laboratories' Board of Directors, and is also President and a Director of Du Mont Television & Electronics, Ltd., of Canada, the company's wholly-owned Canadian subsidiary. Dr. Goldsmith joined Du Mont in 1936 as Director of Research. He is active on various committees of the Radio-Electronics-Television Manufacturers Association, the Society of Motion Picture Engineers, the National Association of Radio and Television Broadcasters, the American Institute of Electrical Engineers, and the National Television System Committee.

Mr. Williams, who was formerly Director of operations for the Du Mont Laboratories' Instrument and Transmitter Division, as well as Director of Government and Special Contracts, joined Du Mont in 1945 as General Manager of the company. Prior to that he had four years' war Service in Washington, D. C. as a staff member of the Radio and Radar Division of the War Production Board. He is a native of Passaic, N. J., and graduated in 1925 from St. Lawrence University in Canton, N. Y. with a Bachelor of Science degree. Mr. Williams has had broad administrative and executive experience in the business and newspaper fields.

Paul G. Andres (A'27) on the staff of the Naval Ordnance Laboratory, Corona, Calif., died recently.

Professor Andres was born in Kitchener, Ontario, on May 14, 1890. He received the BS and EE degrees from Michigan State College, where he taught Electrical Engineering from 1918 to 1921. Beginning in 1921 he served with such firms as Automatic Electric, Newcomb-Hawley, Temple Radio, and P. R. Mallory, in various engineering capacities. He was the holder of over 20 patents awarded for his design and development work for these companies. After two years as Chief Engineer for the State Radio System in Indiana, he became a Consulting Engineer in 1936, specializing in patent work relating to electronics and electrical engineering.

In 1939 he returned to teaching as Associate Professor at Illinois Institute of Technology. During the war he was Director of the I.I.T. Signal Corps Training Program and ESMWT program. He was given an indefinite leave of absence from the Institute because of ill health in 1946, and in 1952 he assumed his duties as Patent Adviser to the Naval Ordnance Laboratory.

He was co-author of "Basic Mathematics for Engineers," and his "Survey of Modern Electronics" was published in 1950. He was a member of Eta Kappa Nu.

IRE People

W. H. Martin

William H. Martin (SM'46), Vice-President in charge of station apparatus and outside plant development, quality assurance, and design engineering of Bell Telephone Laboratories, Inc., has resigned his post to become Deputy Assistant Secretary of Defense in charge of Applications Engineering.

Mr. Martin was born in Maryland in 1889. He attended Johns Hopkins University, receiving his B.A. degree in 1909. He then attended the Massachusetts Institute of Technology, from which institution he received the B.S. degree in 1911. Immediately upon his graduation he joined American Telephone & Telegraph Co., in the Engineering Department, and later the Department of Development and Research. In 1934, he joined the Bell Telephone Laboratories, Inc., and has been affiliated with them until the present time. He has played a responsible part in the development of transmission instruments, microphones, and in the establishment of a sound basis of transmission measurements over the last 35 years.

Mr. Martin is a Fellow of the American Institute of Electrical Engineers, and of the Acoustical Society of America.

❖

William C. Brown (A'39–VA'39), manager of Raytheon Manufacturing Company's magnetron research and development laboratories, has recently been appointed an assistant vice president of the company.

Mr. Brown is a graduate of Iowa State College, and holds a Master's degree in electrical engineering from the Massachusetts Institute of Technology. He began his technical career with RCA, taking special training there and working on radio transmitter development. Mr. Brown joined Raytheon in 1940, working first in the small tube section of the receiving tube division. He was instrumental in developing new tube types for proximity fuses which revolutionized anti-aircraft warfare and advanced the science of guided missiles. Subsequently, he worked on high frequency triodes, which were used in radiosonde balloon transmitters. In 1941, Mr. Brown was transferred to the equipment division to work on microwave components. The following year, due to the wartime necessity of magnetron development to improve the quality of radar equipment, Mr. Brown's services were requisitioned by the power tube division, which eventually placed him in charge of the magnetron research and development facilities, still under his jurisdiction.

In recognition of his outstanding work on magnetrons and other tubes, he was awarded the Naval Ordnance Development Award in 1945, and in 1947 the Certificate of Commendation for outstanding service during World War II.

Mr. Brown is a member of the honorary engineering societies, Tau Beta Pi and Eta Kappa Nu.

❖

Correction

On page 364 of IRE People, in the IRE News and Radio Notes Section of the January issue of the PROCEEDINGS OF THE I.R.E., **Donald P. Wise** (SM'52) was referred to as the former Chief Engineer for the Westinghouse Radio Stations, Inc., WBZ-AM-FM-TV, in Boston, Mass.

W. W. Hauser has been Chief Engineer of the Boston Westinghouse Stations for the past eleven years. Mr. Wise served as a member of his staff.

Books

High Fidelity Techniques by John H. Newitt

Published (1953) by Rinehart & Co., Inc., 232 Madison Ave., New York, N. Y. 461 pages+6-page index+17-page appendix+xvii pages. 199 figures. 9¼×6¼. $7.50.

John H. Newitt is a D.I.C. Staff Member at the Massachusetts Institute of Technology.

This book is an attempt to "boil down" the progress to date on the subject of high fidelity. The author has tried in many ways to separate fact from fiction and discuss the contradictory opinions which prevail. He has not, however, been able to reconcile these differences in any definite manner.

The book is intended for practicing engineers, home construction hobbyists, radio service men and professional audio technicians. It fulfills to a large extent the objective for the home construction hobbyists and the radio service men, but lacks the broad base of application necessary for the professional audio technician.

Sections of the book are devoted to the choosing, buying and setting up or installation of equipment. An indication of the rapidity with which new high fidelity equipment is appearing on the market is manifest by the fact that the majority of the equipment illustrated as acceptable equipment for the home is several years old and not now available for sale as new equipment.

There are a few technical inaccuracies here and there. The author has referred many times to the work of an eminent acoustical research worker in the field but has consistently misspelled his name.

In the discussion on the elimination of "wow," the author has treated the term as a low frequency rather than a low rate of change in frequency.

The chapter on reproducer enclosures is well presented and gives the technician and hobbyist valuable information on practical considerations. The author is commended for emphasizing the fact that phase shift is an important consideration in high fidelity equipment.

The book is recommended to those readers who wish to become acquainted with a talking knowledge on the subject of high fidelity in its many interpretations.

John K. Hilliard
Altec Lansing Corporation
Beverly Hills, Calif.

Practical Television Engineering—Second Edition by Scott Helt

Published (1953) by Rinehart & Company, Inc., 232 Madison Avenue, New York 16, N. Y. 699 pages +14-page index+3-page abbreviations and symbols +30-page glossary+xvi pages. 420 figures. 9¼×6¼. $7.50.

Scott Helt is with the Research Division of the Allen B. Du Mont Laboratories, Inc.

The first edition of this book, published in 1950, was a welcome addition to the literature, in that it treated in detail many topics, particularly in the studio and transmitter phases of television engineering, not then available in book form. The second edition, now issued three years later, is disappointing because the author has not taken full advantage of his opportunity to bring the book up to date. All but about 50 pages of the 744 pages in the second edition are identical to the first edition; it can hardly be argued that this minor revision in any way reflects the progress of the art during the three-year interval. For example, the second edition illustrates receiver IF amplifier design using the 20-mc intermediate frequency values which are now almost completely supplanted by the 40-mc values on which the post-freeze television allocation is based. Among tubes suitable for IF amplifiers mentioned in this second edition are the 1852 and 1232, which can no longer be found in the catalogs and have not been used in any post-war commercial receiver. Only 16 pages are devoted to the vastly important recent developments in uhf and color television, and the NTSC system rates just four paragraphs.

For all this, the book contains much valuable information as of 1950, and much of it is currently valuable particularly in the transmitter and studio end of the business. The owner of the first edition can hardly be encouraged to invest in the second. Others will find it worthwhile as a review of current practice in vhf television broadcasting. For details, refer to the review ofthe first edition, which appeared in the PROCEEDINGS OF THE I.R.E., July, 1951, page 849.

Donald G. Fink
Philco Corporation
Philadelphia, Pa.

Books

Electron Optics by O. Klemperer (Second Edition)

Published (1953) by the Cambridge University Press, Bentley House, London, N.W. 1, England, and 32 E. 57th Street, New York, N. Y. 437 pages+11-page index+5-page appendix+17-page bibliography +xiii pages. 167 figures. 5¾×8½. $9.50.

Dr. Klemperer is Assistant Professor and Reader at Imperial College, University of London.

The author, in his preface, states that "the present book is intended to serve a twofold purpose: first, to introduce the student to a specialized subject, and secondly, to present the research worker or the designer of electron optical gear with all the basic principles and the most essential quantitative information on the subject and to be a guide to that literature where all available details can be found." While the subject is specialized, the fields of its application are widely scattered. They range from television pick-up tubes to beta-ray spectrometers, and from klystrons to electron microscopes. These are all, ambitiously, drawn within the covers of this book, which is four times longer than the first edition.

The earlier chapters on field plotting, ray tracing, lenses, lens errors and aberrations cover well-charted ground. They are less precise and lucid than one would wish in a student's text, but a physicist should come to no harm in reading them.

The chapters which follow deal with space charge, emission systems, electron lenses and emission systems with line focus, and deflecting fields. These collect information which will be of more interest to the designer. Much of it has not previously been collected in a single text. A valuable feature of the book is a bibliography of about 500 papers extending up to 1952. The last chapter describes some applications of electron optics in industry and research.

It is hardly to be expected that one man should write definitively about all the fields of application of electron optics. The sections on electron microscopes are noticeably weak. In general the book will be of more interest to the engineer than the physicist. He should read it as an extended review rather than as a textbook.

The printing and binding should be a challenge to other publishers.

S. G. Ellis
RCA Laboratories, Inc.
Princeton, N. J.

Principles of Modern Acoustics by George W. Swenson, Jr.

Published (1953) D. Van Nostrand Company, Inc., 250-4th Ave., New York 3, N. Y., and D. Van Nostrand Company, Ltd., 25 Hollinger Road, Toronto, Ont., Canada. 211 pages+4-page index+5-page appendix+vii pages. 9 figures. 6×9¼. $4.00.

The Principles of Modern Acoustics is a text suited for an intermediate college course for students in Physics and Engineering. The material is well presented, the language is lucid, and the mathematics are well within the scope of college upperclassmen. Problems at the end of each chapter illustrate practical applications.

The arrangement of subjects follows a conventional pattern. In Chapter I there is a review of oscillations followed by a brief treatment of electromechanical analogies and of elementary transducers. Chapters II and III are devoted to strings and membranes. In Chapter IV, the author treats acoustic waves, and in Chapter V, radiators, reflectors, and horns. Chapter VI deals with electroacoustic analogies and acoustic elements. Chapter VII deals with elements of architectural acoustics and Chapter VIII, with speech and hearing. As an interesting and useful innovation, Chapter IX is entitled Approximate Methods for Acoustics Problems and it contains a convenient collection of methods for attacking certain problems in acoustics which do not yield readily to conventional mathematical treatment. The MKS system of units is used throughout the book.

Among the noteworthy pedagogical aspects of the book is its emphasis on the subject of analogies. In dealing with mechanical systems, the author gives preference to the "force-current" analogy, and for acoustical system, to be consistent, he chooses the corresponding "pressure-current" scheme. The reviewer wishes to point out that authorities in the field are not in agreement on this subject, and confronted with a choice of but a single analogy many would have chosen the classical "force-voltage" and "pressure-voltage" schemes.

A course covering the subject-matter of the text should give the student a thorough grounding in the principles of modern acoustics and prepare him for more advanced treatises. The book is a welcome addition to the library on Acoustics.

Benjamin B. Bauer
Shure Brothers, Inc.
Chicago, Ill.

Information Theory—and Its Engineering Applications by D. A. Bell

Published (1953) by Sir Isaac Pitman & Sons, Ltd., Pitman House, Parker St., Kingsway, London, W. C. 2, England, and Pitman Publishing Corporation, 2 W. 45th St., New York, N. Y. 119 pages+21-page index +17-page appendix+viii pages. 27 figures. 5½×8¾. $4.00.

D. A. Bell is a Reader in electromagnetism at the University of Birmingham, Birmingham, England.

In the preface to "Information Theory and its Engineering Applications" the author states that the chief motive in writing this book was the desire to make available to the "professional engineer" (the quotes are the author's). . . . the substance of developments published since 1948 in the theory of the performance of communication systems. For this purpose, the scope of the book is excellent. It starts with an introduction giving the binary measure of information which is followed by a discussion of enthropy and information. The author gives a very interesting discussion as to why information should be equated to negative enthropy. The author pointed out in this connection that he arrived at this line of thought at the same time that the work of P. M. Woodward and his associates along these lines became available. Band-width and signaling speed are then discussed and is followed by a chapter on signal to noise ratio and then a chapter on coding. These chapters are most interesting and flashes of deep understanding of the problems by the author are present but the treatment is much too brief. This whole discussion only takes 32 pages and there really is not enough space to fully present the material. A few pages are even devoted to a discussion of Kelvin's work on submarine cables and his proposals for rapid signalling, which is very interesting historically, but rather wasteful of space in such a short text. The next to the last chapter on practical applications of the theory is rather condensed and only gives a very short summary of the various applications. This is followed by a chapter on Weiner's Theory of Filtering.

There is a great need for a book for engineers on this subject and the author did a good job on most of the material as far as he went. The treatment, however, being large in scope and sparse in text, is much too brief to give an engineer a good basic understanding of the subject so that a practicing engineer could apply the principles to his specific problems. Probably the best use of the book would be for young engineers, engineering executives and salesmen, if they are willing to overlook the mathematics, to give them a talking acquaintance with the newer principles of information theory.

Nathan Marchand
Marchand Electronic Laboratories
Byram, Conn.

Survey of Automatic Digital Computers

The Office of Naval Research has recently completed a tabulation of data on automatic digital computers throughout the world, comprising 98 pages on as many models. Three indexes are included. This *Survey of Automatic Digital Computers* is being published by the Office of Technical Services, Department of Commerce, Washington 25, D. C., at a price of $2.00, payable to the Treasurer of the United States. It is identified by PB no. 111-293.

Abstracts and References

Compiled by the Radio Research Organization of the Department of Scientific and Industrial Research, London, England, and Published by Arrangement with that Department and the *Wireless Engineer*, London, England

Note: The Institute of Radio Engineers does not have available copies of the publications mentioned in these pages, nor does it have reprints of the articles abstracted. Correspondence regarding these articles and requests for their procurement should be addressed to the individual publications, not to the IRE.

The Index to the Abstracts and References published in the PROC. I.R.E. from February 1953 through January 1954 is published by *Wireless Engineer* and included in the March 1954 issue of that journal. Copies of this issue may be purchased for $1 (including postage) from the Institute of Radio Engineers, 1 East 79th Street, New York 21, N.Y. As supplies are limited, the publishers ask us to stress the need for early application for copies. Included with the Index is a selected list of journals scanned for abstracting with publishers' addresses.

Acoustics and Audio Frequencies....... 769
Antennas and Transmission Lines...... 769
Automatic Computers................. 770
Circuits and Circuit Elements.......... 771
General Physics.................... 773
Geophysical and Extraterrestrial Phenomena......................... 773
Location and Aids to Navigation....... 775
Materials and Subsidiary Techniques... 775
Mathematics....................... 777
Measurements and Test Gear......... 777
Other Applications of Radio and Electronics........................... 778
Propagation of Waves................ 779
Reception......................... 779
Stations and Communication Systems.. 779
Subsidiary Apparatus................ 780
Television and Phototelegraphy........ 780
Transmission....................... 781
Tubes and Thermionics............... 781

The number in heavy type at the upper left of each Abstract is its Universal Decimal Classification number and is not to be confused with the Decimal Classification used by the United States National Bureau of Standards. The number in heavy type at the top right is the serial number of the Abstract. DC numbers marked with a dagger (†) must be regarded as provisional.

A new section has been introduced covering the general technique of electromagnetic waves, oscillations and pulses (i.e. transmission lines and circuits), as distinct from specific applications to telecommunications. The new section is numbered 621.37, with subdivisions. Full details of the new classification, and of the numbers which become obsolete as a result of its introduction, are given in PE Note 535, obtainable from The International Federation for Documentation, Willem Witsenplein 6, The Hague, Netherlands, or from The British Standards Institution, 2 Part Street, London, W.1., England.

Section 621.396.67, dealing with Antennas, has been modified and expanded; details of the new classifications are given in PE Note 519.

Section 621.396.96, with subdivions, has been introduced to cover Radar; details of the new classifications are given in PE Note 518.

New Subject Section

A Section headed Automatic Computers has been introduced.

ACOUSTICS AND AUDIO FREQUENCIES

534.213.4 **611**

The Transient Motion of Sound Waves in Tubes—J. D. Pearson. (*Quart. Jour. Mech. Appl. Math.*, vol. 6, part 3, pp. 313–335; Sept., 1953.) Using Heaviside operators, a formula is obtained for the velocity potential in an infinite tube of uniform cross section, and an asymptotic solution is derived by the method of steepest descent. For a tube of slightly variable cross section a series solution is obtained. The case of a tube of nearly rectangular cross section with a longitudinal harmonic distortion is considered in detail.

534.213.4:534.61 **612**

Experiments on the Propagation of Plane Sound Waves in Tubes—D. E. Weston and I. D. Campbell. (*Proc. Phys. Soc.*, vol. 66, pp. 769–774; Sept. 1, 1953.) For measurements in the adiabatic region an acoustic interferometer was used, with a magnetostriction source. Values of attenuation and velocity were determined with tubes of radius 0.013 cm and upward, at frequencies from 10 to 20 kc, for various tube materials and gases. The results confirm the modified Kirchhoff's formula. For the transition region between adiabatic and isothermal flow, measurements were made with tubes of radius 0.02 cm. The attenuation results are a little higher than the calculated values, the velocity results are in general agreement with theoretical values.

534.4:534.78 **613**

Speech Communication Research—G. Fant. (*IVA, Stockholm*, vol. 24, pp. 331–337; 1953. In English.) The formation of a speech-communication research group of the Division of Telegraphy and Telephony of the Swedish Royal Institute of Technology is announced and an outline is given of its program, which covers both engineering and linguistic aspects. Methods for measuring the efficiency of communication systems for handling messages in Swedish are being studied.

534.6:534.321.9 **614**

Acoustic-Optical Image Conversion—G. Spengler. (*NachrTech.*, vol. 3, pp. 399–402; Sept., 1953.) A survey is made of the principal methods used in the visual presentation of sound and ultrasonic fields in solids, liquids and gases. The characteristics of an ideal converter system are discussed and the problem of eliminating spurious effects due to reflections from the converter is considered.

534.614 **615**

The Velocity of Sound in Air at Low Pressures—D. E. Caro and L. H. Martin. (*Proc. Phys. Soc.*, vol. 66, pp. 760–768; Sept. 1, 1953.) Loudspeakers were arranged at the ends of a tube and measurements were made of the time of transit of a pulse between two microphones mounted about 4 m apart in the wall of the tube, using the two loudspeakers alternately. Frequencies of 250 cps and 1 kc were used. The mean velocity at 20 degrees C. is found to be 343.40 ±0.02 m/s, and is independent of pressure over the range 5–760 mm Hg.

534.846.6 **616**

Investigation of the Acoustics of Large Halls using Models—R. Lamoral and R. Trembasky. (*Onde élect.*, vol. 33, pp. 570–575; Oct., 1953.) 1-ms pulses of a 30-kc signal from an ionophone were transmitted via a tube to a 1/30-scale model. Echoes received on a miniature microphone in the model were recorded by cro.

621.395.61:621.375.132 **617**

Note on the Application of Negative Feedback to Electroacoustic Devices—P. Poincelot. (*Onde élect.*, vol. 33, pp. 576–577; Oct., 1953.) The improvement of the response curve of an electrodynamic microphone on application of negative feedback [1068 of 1950 (Chavasse and Poincelot)] is mentioned as an illustration of the advantages of this technique.

621.395.623.7 **618**

Power Capacity of Loudspeakers—P. S. Veneklasen. (*Trans. IRE.*, vol. AU-1, pp. 5–6; Sept./Oct., 1953.) The power-handling capacity is determined by observing the departure from linearity of the acoustic-output/electric-input curves, using octave bands of thermal noise. This method is under consideration for inclusion in a new I.R.E. Standard, and comments are invited by the I.R.E. Electroacoustics Committee.

621.395.625.3:534.862:534.76 **619**

Stereophony in the Cinema—J. Moir. (*Wireless World*, vol. 60, pp. 6–9; Jan., 1954.) Systems using multiple magnetic sound tracks in conjunction with wide screens are described.

621.395.625.3:679.5 **620**

The Manufacture of Magnetic Tapes—C. P. Fagan. (*Plastics*, vol. 18, pp. 323–324; Sept., 1953.) Materials and processes used in the manufacture of plastic-based tapes are described; advantages of polyester-resin base materials are mentioned.

ANTENNAS AND TRANSMISSION LINES

621.315.212:621.372.2 **621**

Highly Flexible Coaxial Cable with Helical Outer Conductor—H. Weiss. (*Onde élect.*, vol. 33, pp. 516–526; Aug./Sept., 1953.) Cable sections suitable for replacing rotary joints are studied, the attenuation being of only secondary importance in this case. The amounts of power transmitted internally and externally are calculated separately; the externally transmitted power becomes zero for a helix pitch of 90 degrees (i.e. ordinary coaxial cable). Dielectric and ohmic losses are discussed and the effect of the distribution of the outer conductor is investigated.

621.315.212:621.372.8 **622**

The Transverse Electromagnetic Lecher Wave in Coaxial Cable as a Degenerate Waveguide Wave—H. Kleinwächter. (*Arch. elekt. Übertragung*, vol. 7, pp. 467–469; Oct., 1953.) The Transverse Lecher wave, which is a degenerate E_0 wave, is shown to be the only mode without an axial component which can be propagated in a coaxial component which can be propagated in a coaxial cable without attenuation.

621.372.2 623

An Investigation of the Characteristics of Cylindrical Surface Waves—H. M. Barlow and A. E. Karbowiak. (*Proc. IEE*, part III, vol. 100, pp. 321–328; Nov., 1953. Discussion, pp. 341–347.) An account is given of an experimental study using a frequency of about 10 kmc. For accurate work, the line used was about 4 feet long, short-circuited at both ends by transverse metal plates and excited at resonance, the usual launching horns being dispensed with. Descriptions are given of an axial standing-wave indicator and an instrument for determining the radial field distribution, both designed as far as possible to avoid disturbing the field. Measurements of the decay coefficients of no. 24 swg. Cu wire thickly coated with polythene diverged widely from the values derived from Goubau's approximate theory. On revising the assumptions in the theory, values in agreement with the experimental results were obtained. The surface-wave resonator can also be used for measuring the surface reactance of corrugated surfaces.

621.372.2 624

Surface Waves—H. M. Barlow and A. L. Cullen. (*Proc. IEE*, part III, vol. 100, pp. 329–341; Nov., 1953. Discussion, pp. 341–347.) Unified theory is presented for various forms of surface wave, namely the Zenneck wave, the radial cylindrical surface wave, and the Sommerfeld-Goubau or axial cylindrical surface wave. The significance of the Brewster angle of incidence, for which a wave suffers no reflection, is established. The parallel-plate transmission line is discussed and the transition is demonstrated from the TEM wave supported when the plates are close together to the two separate Zenneck waves when the plates are separated by a sufficient distance. The effect of bends in the line is considered and methods of reducing radiation are explained. Launching processes are surveyed with particular reference to the Brewster-angle approach.

621.372.2:538.566 625

The Types of Wave which may exist near a Guiding Surface—J. Brown. (*Proc. IEE*, part III, vol. 100, pp. 363–364; Nov., 1953.) It is shown theoretically that the waves near a guiding surface can be classified as guided surface waves, evanescent fields or radiation fields. The evanescent fields differ from those in a transmission line or waveguide in that all values of attenuation constant are possible.

621.372.2.012.11 626

The Circle Diagram for Reflection Coefficient—E. Thinius. (*Fernmeldetech. Z.*, vol. 6, pp. 468–469; Oct., 1953.) A chart is presented from which it is possible to obtain the curve for reflection coefficient as a function of frequency.

621.372.8 627

The Influence of Bends and Ellipticity on the Attenuation and Propagation Characteristics of the H_{01} Circular Waveguide Mode—G. D. Sims. (*Proc. IEE*, part IV, vol. 100, pp. 23–33; Oct., 1953.) Measurements made with a wave analyzer, mainly at a wavelength of 3.2 cm, are reported. Jouguet's theory of propagation in a curved waveguide (3786 of 1947) is discussed and a brief account is given of experiments confirming it. The value of 3.4 db/km obtained for the attenuation in a long closed Cu waveguide, using a multiple-reflection technique, is about three times the theoretical figure; the difference is attributed to losses due to ellipticity and surface roughness.

621.372.8 628

Reflection of Electromagnetic Waves at Inhomogeneous Boundary Surfaces with a Periodic Structure Perpendicular to the Electric Vector—R. Müller. (*Arch. elekt. Übertragung*, vol. 7, pp. 492–500; Oct., 1953.) The particular cases considered mathematically include the incidence of an H_{10} wave in a rectangular waveguide on a slit diaphragm, the incidence of a plane em wave on a stack of matching plates, and the incidence of an H_{10} wave on a discontinuous rectangular coupling section.

621.372.8 629

X-Band Rotary Joint—H. J. Riblet and R. L. Williston. (*Trans. IRE*, vol. MTT-1, pp. 23–24; March, 1953.) A transition section for operation with high power takes the form of a tapered ridged waveguide; voltage swr is not greater than 1.02 over an 11 per cent frequency band.

621.396.67 630

Some Optical Aspects of Antenna Radiation and Reception—J. L. Salpeter. (*Philips Tech. Commun., Australia*, no. 3, pp. 3–10; 1953.) Similarities and differences between the em radiations constituting light and those constituting radio waves are outlined; the former are usually noncoherent, the latter coherent. Differences in the design of radiators, reflectors and lenses for light waves and those for radio waves are explained on this basis.

621.396.67+621.372.8](083.74) 631

I.R.E. Standards on Antennas and Waveguides: Definitions of Terms, 1953—(Proc. I.R.E., vol. 41, pp. 1721–1728; Dec., 1953.) Standard 53 IRE 2S1.

621.396.676 632

Short Antennas for Mobile Operation—J S. Belrose. (*QST*, vol. 37, pp. 30–35, 108; Sept., 1953.) Simple numerical calculations are presented of the radiation resistance, efficiency, effective height, input reactance, etc., of unloaded and loaded vertical aerials near the ground. The results are in good agreement with those determined from field-strength measurements.

621.396.677.3 633

A High-Resolution Aerial System of a New Type—B. Y. Mills and A. G. Little. (*Aust. Jour. Phys.*, vol. 6, pp. 272–278; Sept., 1953.) A horizontal antenna system, in the form of crossed arrays consisting of dipoles all of which are parallel to each other, is described. The experimental model, with 120-foot cross arms, operates at 97 mc; the beam width is 8 degrees. Work on a 1 degree-beam-width system for operation at about 80 mc is in progress. The elementary theory and results of some radio-astronomy measurements are given.

621.396.677.31 634

A Simplified Calculation for Dolph-Tchebycheff Arrays—G. J. van der Maas. (*Jour. Appl. Phys.*, vol. 24, p. 1250; Sept., 1953.) An alternative series is derived which is more suitable for the numerical calculation of the currents in individual elements than that given by Barbiere (1211 of 1952.)

621.396.677.71:535.42 635

Babinet's Principle and the Slot Antenna—J. L. Salpeter. (*Philips Tech. Commun., Australia*, no. 4, pp. 3–15; 1953.) Simple theory of the slot antenna is developed from optical diffraction theory. The complementary aspects of dipoles and slot antennas are discussed.

621.396.677.73 636

Calculation of the Gain of Small Horns—E. H. Braun. (Proc. I.R.E., vol. 41, pp. 1785–1786; Dec., 1953.) A simple procedure is given for extending the range of the curves presented by Schelkunoff ("Electromagnetic Waves") to cover horns whose dimensions are small compared with λ.

621.396.677.73:621.396.677.8 637

Antennas Fed by Horns—B. Berkowitz. (Proc. I.R.E., vol. 41, pp. 1761–1765; Dec., 1953.) Formulas are derived for the *E*- and *H*-plane radiation patterns as functions of illumination taper. The case of a lens or reflector associated with two contiguous horns stacked in either of the principal planes is investigated. By introducing an "illumination factor," defined in terms of physical dimensions, the following properties are related:—(*a*) loci of half-power beam widths, nulls and side-lobe peaks; (*b*) illumination taper at edge of lens or reflector; (*c*) crossover power; (*d*) spillover power; (*e*) gain referred to the feed horn.

621.396.677.8:538.52:537.311.5 638

On the Current Induced in a Conducting Ribbon by a Current Filament Parallel to it—Moullin. (*See* 704.)

621.396.677.85 639

Artificial Dielectrics having Refractive Indices less than Unity—J. Brown. (*Proc. IEE* part IV, vol. 100, pp. 51–62; Oct., 1953. Summary, *ibid.*, part III, vol. 100, pp. 319–320; Sept., 1953.) Two types are considered, the first comprising an array of conducting rods and the second a set of perforated parallel conducting plates. Both are designed for operation with a wave polarized so that its electric field is parallel to the conducting elements. The method of calculating the effective refractive index is indicated. The reflection occurring at the interface between the medium and free space is investigated.

AUTOMATIC COMPUTERS

681.142 640

Programme Design for the C.S.I.R.O. Mark I Computer: Part 1—Computer Conventions—T. Pearcey and G. W. Hill. (*Aust. Jour. Phys.*, vol. 6, pp. 316–334; Sept., 1953.) See also 1050 of 1953 (Beard and Pearcey).

681.142 641

Programme Design for the C.S.I.R.O. Mark I Computer: Part 2—Programme Techniques—T. Pearcey and G. W. Hill. (*Aust. Jour. Phys.*, vol. 6, pp. 335–356; Sept., 1953.) Part 1: 640 above.

681.142 642

Recent Electronic Computers and their Applications—D. Dainelli and E. Aparo. (*Ricerca sci.*, vol. 23, pp. 1528–1549; Sept., 1953.) Digital computers are described and compared in respect of operating speed and structure.

681.142 643

A Mathematical Basis for an Error Analysis of Differential Analyzers—K. S. Miller and F. J. Murray. (*Jour. Math. Phys.*, vol. 32, pp. 136–163; July/Oct., 1953.)

681.142 644

Analogue Computer for Aircraft Design—(*Elect. Jour.*, vol. 151, pp. 893–894; Sept. 18, 1953.) A compact general-purpose instrument designed for economical quantity production.

681.142:531.77 645

An Analog-to-Digital Converter—A. D. Scarbrough. (*Trans. IRE*, vol. EC-2, pp. 5–7; Sept., 1953.) A device for giving the angular position of a slowly rotating shaft as a binary number uses a mechanical counter which goes from zero to full capacity during one revolution of the shaft. The counter may comprise a series of cams associated with switches. On application of a reading pulse, the number registered by the counter is made available as a pattern of pulses, the arrangement being suitable as an input device for a digital computer.

681.142:621–526 646

Servo Systems for performing Mathematical Operations—E. Wall. (*Product Eng.*, vol. 24, pp. 134–140; Sept., 1953.) By combining servomechanisms with computing systems involving mechanical or electrical analogies loading effects, which tend to introduce inaccuracies, are eliminated. An outline is given of procedures for addition and subtraction, determination of powers and roots, solution of triangles, and integration.

681.142:621.385 647

The Univac Tube Program—T. D. Hinkelman and M. H. Kraus. (*Trans. IRE*, vol. EC-2, pp. 8–12; Sept., 1953.) Account of an integrated program, starting with the design and initial selection, for ensuring reliable performance of tubes in a large-scale computer.

CIRCUITS AND CIRCUIT ELEMENTS

621.3.011.21.012.1 648

Rapid Parallel-Z Calculations—L. Storch. (*Tele-Tech*, vol. 12, pp. 91–93, 193; Aug., 1953.) Use of a special graph paper with both polar and rectangular coordinates facilities the calculation. A ruler is the only instrument required in this graphical method.

621.3.012:[621.318.42+621.372.4 649

The Calculation of Nonlinear Networks by means of Composite-Straight-Line Characteristics—A. Hochrainer. (*Elektrotech. u. Maschinenb.*, vol. 70, pp. 376–386; Sept. 1, 1953.) Many circuit problems are simplified by substituting for an actual curved characteristic an approximation built up of rectilinear sections. Use of the method is illustrated by studying the characteristics of iron-cored coils with and without hysteresis, and with and without magnetic bias, and by analysing the free oscillations of a circuit including an iron-cored coil. Emphasis is laid on the point that the actual shape of the nonlinear characteristic is less significant than the simple fact of its deviation from linearity.

621.3.018.78 650

Harmonic and Intermodulation Distortion in "Power Law" Devices—D. G. Lampard. (*Proc. IEE* part IV, vol. 100, pp. 3–7; Oct., 1953.) Explicit expressions are derived for the intermodulation components produced when two sinusoidal voltages are applied simultaneously to a device, such as a diode, whose transfer characteristic can be represented by a simple power-law formula. Results of practical importance in intermodulation-distortion testing are presented graphically.

621.315.332+621.316.8+621.319.4 651

Components for Severe Conditions of Use—L. Podolsky. (*Onde élect.*, vol. 33, pp. 510–515 Aug./Sept., 1953.) A discussion of the factors to be considered in the design of capacitors and resistors for use under extreme temperature and humidity conditions, particularly when the components are required to be as small as possible. The use of ceramic-covered wire for the windings of transformers etc. to withstand high temperatures is mentioned.

621.316.726.029.6:621.376.3 652

Frequency Discrimination and Stabilization of Square-Wave-Modulated Microwave Transmissions—C. H. M. Turner. (*Proc. IEE*, part III, vol. 100, pp. 381–383; Nov., 1953.) The method described is a modification of that due to Aurell (M.I.T. Technical Report No. 30). The frequency of the oscillations from a reflex klystron is compared with the resonance frequency of a high-Q cavity, and a correction voltage depending on the frequency difference is fed back to the klystron reflector electrode via the modulator, where it is combined with the square-wave modulation voltage. The method of alignment of the microwave circuits is discussed in detail, and the effect of misalignment on the discriminator characteristics is shown.

621.316.86:537.312.6 653

Properties and Applications of Thermistors—J. Bleuze. (*Onde élect.*, vol. 33, pp. 497–509 and 578–590; Aug./Sept. and Oct., 1953.)

621.316.89.029.5 654

Theory of the Boella Effect—U. Tiberio. (*Alta Frequenza*, vol. 22, pp. 184–187; June /Aug., 1953.) A discussion of the mechanism causing the drop in the resistance of composition resistors at hf (1934 Abstracts, p. 454). A similar variation of resistance with frequency has been observed in electrolytic solutions (Debye-Falkenhagen effect). Comparative measurements were made on 30-kΩ resistors of three different types, namely (*a*) ceramic rod with helical carbon film ("low-resistance type"), (*b*) carbon/resin composition in ceramic case ("high-resistance type"), and (*c*) capillary tube containing a solution of CuSOi in water (electrolyte type). The Boella effect was most marked in case (*b*). Variation of resistance with electric field strength is also observed. The explanation given is alternative to that of Howe (3226 of 1935).

621.318.4.015.4 655

Natural Frequencies of Coils and Windings—P. A. Abetti and F. J. Maginniss. (*Elect. Eng.*, N.Y., vol. 72, p. 781; Sept., 1953.) Digest only. Calculations for an equivalent circuit consisting of reactors only were made using (*a*) punched-card equipment, (*b*) an ac-network analyser. The effect of neglecting the mutual inductance between elements, partly or completely, is shown graphically. Very close agreement with measured natural frequencies was obtained.

621.318.423.011 656

Air-Core Coil Design for Crossover Networks—A. Meyer. (*Trans. IRE*, vol. AU-1, pp. 9–11; Sept./Oct., 1953.) Simple analysis is given for determining the correct wire gauge and optimum coil dimensions for specified values of Q and L. Results are shown in charts, and numerical examples illustrate their use.

621.318.435.3.025.3:621.375.3 657

Three-Phase Transductor Circuits for Magnetic Amplifiers—A. G. Milnes. (*Proc. IEE*, part IV, vol. 100, pp. 1–2; Oct., 1953.) Discussion on 949 of 1953.

621.318.57:621.314.7 658

Transistors: Theory and Application: Part 10—Switching Circuits using the Transistor—A. Coblenz and H. L. Owens. (*Electronics*, vol. 26, pp. 186–191; Dec., 1953.) Counter circuits, relaxation oscillators, etc., using point-contact transistors are described. Part 9: 341 of February.

621.318.57:621.314.7 659

The Phase-Bistable Transistor Circuit—R. H. Baker, I. L. Lebow, R. H. Rediker, and I. S. Reed. (PROC. I.R.E., vol. 41, p. 1760; Dec., 1953.) Corrections to paper noted in 3515 of 1953.

621.318.572:621.385.832 660

The E1T Decade Counter Tube—(*Electronic Applic. Pull.*, vol. 14, pp. 71, 76; May, 1953.) Corrections and addendum to paper noted in 603 of February.

621.372 661

A Note on the Network Postulates—M. G. Arsove. (*Jour. Math. Phys.*, vol. 32, pp. 203–206; July/Oct., 1953.) Kirchhoff's law, that the sum of the potential differences about any closed path of branches is zero, is replaced by a version making no explicit references to paths of branches. The resulting law can be interpreted geometrically in terms of orthogonal subspaces of a certain vector space. The network definition given is readily shown to be invariant under changes of basis. The equivalence between the new definition and the classical one is established.

621.372 662

The Return-Difference Matrix in Linear Networks—L. Tasny-Tschiassny. (*Proc. IEE*, part IV, vol. 100, pp. 39–46; Oct., 1953.) Bode's concept of the "return difference" is generalized by replacing the quantities concerned by matrices. A formula for the "fractionated gain" is derived which is a generalization of Thévenin's theorem. Formulas are also derived for the stability of a circuit, for the variation of its output as a result of imperfections of the circuit elements, and for the input and output impedance. The method is particularly useful for analysing multiple-loop feedback circuits.

621.372 663

A Graphical Contribution to the Analysis and Synthesis of Electrical Networks—O. P. D. Cutteridge. (*Proc. IEE*, part IV, vol. 100, pp. 83–90; Oct., 1953. Digest, *ibid.*, part III, vol. 100, pp. 377–379; Nov., 1953.) "The contribution of the poles and zeros of a network function to the steady-state characteristics at real frequencies is considered by means of vectors, and the connection between attenuation and phase is thereby accentuated. Bode's relation between attenuation and phase in minimum-phase networks is derived by considering the contributions from individual singularities and using a known definite integral in a real variable. Details are derived for the construction of a series of templates, useful for finding pole-zero positions which yield certain attenuation, phase and delay characteristics, and vice versa." The method is illustrated by examples including the estimation of the phase and delay characteristics corresponding to the given attenuation characteristic of a minimum-phase wide-band amplifier.

621.372 664

The Relations between Circuit Pass Band and Signal-Build-Up Time—P. Poincelot. (*Compt. Rend. Acad. Sci.* (*Paris*), vol. 237, pp. 1217–1218; Nov. 16, 1953.) Two passband criteria are discussed, namely (*a*) the bandwidth between the 3-db points and (*b*) the bandwidth defined in terms of spectral distribution of energy. It is shown that these are not uniquely related and that it is not possible to determine the time constant of a circuit solely from a knowledge of its bandwidth.

621.372.:512.831 665

Voltage-Reference Node—J. Shekel. (*Wireless Eng.*, vol. 31, pp. 6–10; Jan., 1954.) Description of a general method of analyzing linear networks by nodal analysis without specifying the node to which all voltages are referred; the network can be represented by an indefinite admittance matrix, which can be brought to a definite form by omitting the row and column corresponding to a specified reference node. The method is useful for dealing with valve circuits with earthed-grid or earthed-anode stages or with no earthed electrodes.

621.372.2:534.321.9 666

Fused-Quartz Ultrasonic Delay-Line Memory—D. A. Spaeth, T. F. Rogers, and S. J. Johnson. (*Electronics*, vol. 26, pp. 151–153; Dec., 1953.) The digit-storage unit described is of the type comprising a slab of fused quartz providing a folded transmission path. Methods are indicated for eliminating spreading of the ultrasonic beam and mode conversion at the reflecting surfaces, thus reducing the intensity of spurious signals. An ultrasonic frequency of 40 mc is used, and pulses with a dynamic range of 40 db can be stored at rates $>5\times10^6$ /seconds.

621.372.412 667

Some Notes on the Properties and Manufacture of Piezoelectric Quartz Crystals—H. L. Downing. (*Proc. I.R.E.* (*Australia*), vol. 14, pp. 241–248) Oct., 1953.) The frequency stability, temperature coefficient and activity of quartz resonators are discussed, and the relation between these properties and the oscillation frequency of a circuit including the crystal is examined. The performance of some typical units is shown graphically.

621.372.413 668

Doubly Compensated Tunable Cavity—T. S. Saad. (*Trans. IRE*, vol. MTT-1, pp. 25–28; March, 1953.) Two-frequency temperature compensation of hermetically sealed cavities filled with dry inert gas is described. A typical performance curve is shown.

621.372.5+621.375.23 669

Differentiating Circuits—R. L. Ford. (*Electronic Eng.*, vol. 25, pp. 519–521; Dec., 1953.) Passive-network and feedback-amplifier types of differentiator are discussed, and the performances of two variants of the latter type are compared.

621.372.5 670

Determination of the Input Impedance of Linear Quadripoles by a Graphical Method—M. Klobe. (*NachrTech.*, vol. 3, pp. 421–424; Sept., 1953.) The data required are the characteristic impedance, the load or terminal impedance and the propagation constant of the quadripole. Two examples are worked out.

621.372.5 671

Build-Up Phenomena in Minimum-Phase Networks—H. Holzwarth. (*Arch. elekt. Übertragung*, vol. 7, pp. 473–477; Oct., 1953.) Wheeler's paired-echo method (3642 of 1939) is used to evaluate the network response to a single pulse and to a step voltage. The method is fundamentally a simplified application of the Fourier integral and is particularly useful for evaluating the distortion with a minimum of computation.

621.372.5 672

The Equivalent *Q* of RC Networks—L. A. Wyatt, D. A. H. Brown, and D. W. R. Wheeler. (*Electronic Eng.*, vol. 25, p. 534; Dec., 1953.) Further comments on 2919 of 1953 (Brown).

621.372.52:621.373.421 673

Theory of Twin-T RC Networks and their Application to Oscillators—A. P. Bolle. (*Jour. Brit. IRE*, vol. 13, pp. 571–587; Dec., 1953.) The conditions are established which the circuit elements must satisfy (*a*) for the network to produce infinite attenuation at one frequency ω_0, and (*b*) for the output to be either in phase or in phase opposition with the input at ω_0 on varying two elements in a particular manner. The slope of the phase/frequency characteristic at $\omega=\omega_0$ is compared with that of a resonant *LC* circuit. One-tube oscillators incorporating such networks are discussed, with particular attention to distortion and stability. Results of measurements on an oscillator are compared with values calculated from theory.

621.372.542.22:621.372.412 674

Design Procedure for Crystal Lattice Filters—W. C. Vergara. (*Tele-Tech.* vol. 12, pp. 86–87; Sept. 1953.) The technique of filter design is described and formulae for the electrical and mechanical constants of −18.5 degrees X-cut quartz crystals are given. A bridge network of two divided-electrode crystals operating at 135 kc has an image impedance of 425 kΩ.

621.372.542.4.029.3 675

The Basic Design of Constant-Resistance Crossovers—N. H. Crowhurst. (*Audio Eng.*, vol. 37, pp. 21–22, 110; Oct., 1953.) A simple mathematical analysis of the attenuation and phase characteristics for constant-resistance filters consisting of up to four elements. The frequency response is shown graphically.

621.372.543.2.029.42 676

A Band-Pass Filter for Low Frequencies—A. H. Silcocks, G. W. Morris, and P. G. M. Dawe. (*Electronic Eng.*, vol. 25, pp. 534–535; Dec., 1953.) Critical comment on 3237 of 1953 and authors' reply.

621.372.543.2.029.63 677

Duplexing Filter Design at 2000 Mc/s—D. R. Crosby. (*Trans. IRE*, vol. MTT-1, pp. 31–38; March, 1953.) The cavity-resonator-type filters described are used in commercial communication equipment with transmitter and receiver operating with a frequency separation of 40 mc; both receiving and transmitting filters have a bandwidth of 20 mc.

621.372.56.029.6 678

A Comparison of the Properties of Certain Materials used in Low-Power Microwave Attenuators—F. A. Benson and R. M. Pearson. (*Electronic Eng.*, vol. 25, pp. 502–505; Dec., 1953.) Results of measurements on Morganite, antistatic gutta-percha and carbon-loaded bakelite indicate that, if suitably sealed to prevent ingress of moisture, Morganite is the best from the point of view of stability.

621.372.57:621.3.018.75 679

D. C. Restoring of Variable-Width Rectangular Pulses—J. van Bladel. (*Electronic Eng.*, vol. 25, pp. 524–525; Dec., 1953.) The well known diode dc restoring circuit is discussed; the effect of deviations of source impedance, diode forward resistance and coupling capacitance from their "ideal" values is investigated. The analysis is illustrated by a practical example.

621.372.57:621.385 680

Starvation Circuits and their Limitations—P. J. Erdle. (*Sylvania Technologist*, vol. 6, pp. 85–88; Oct., 1953.) The under-running of tubes is deprecated on technical grounds. The tubes so operated generally tend to be unstable with variations in the supply voltage and with age.

621.373.4:621.316.726 681

A Controlled-Frequency Oscillator with Frequency "Memory"—J. van Bladel. (*Jour. Sci. Instr.*, vol. 30, pp. 299–301; Sept., 1953.) An arrangement is described in which a phase-comparison afc system is used to keep a first oscillator in tune with a second (pilot) oscillator. At a given instant the control loop is broken; thereafter the first oscillator continues to operate at the frequency at the cut-off instant, and subsequent frequency variations of the pilot oscillator are determined from measurements of the phase difference between the two oscillators. A practical circuit which holds frequencies in a band centered on 50 cps is described.

621.373.4:621.385.3 682

Oscillator Characteristic Equation—V. L. Talekar. (*Wireless Eng.*, vol. 31, pp. 3–6; Jan., 1954.) The equation for an oscillator circuit using a triode is developed in a form involving the differential coefficients of the dynamic resistance of the triode. Measurements on a Hartley oscillator are reported which are in good agreement with the theoretical results over most of the oscillation characteristic. Particular features of the oscillation characteristics are discussed, and the constants of the triode and the tank circuit are deduced from them.

621.373.4:621.396.822 683

Effect of Valve Noise on Oscillators—A. Blaquière. (*Compt. Rend. Acad. Sci.* (*Paris*), vol. 237, pp. 1316–1318; Nov. 23, 1953.) The magnitudes of the tube shot effect and circuit thermal noise in oscillators are compared. When the oscillatory circuit is connected to the grid, the valve noise is relatively negligible; when the oscillatory circuit is connected to the anode, the tube noise preponderates.

621.373.42.029.63 684

Tuned Circuit Oscillators at UHF—W. H. Elkin, (*Marconi Instr.*, vol. 4, pp. 50–54; Sept., 1953.) The design of a disk-seal-triode oscillator for frequencies up to 1 kmc is discussed. The causes of spurious resonance, and their elimination, are considered.

621.373.421 685

High-Frequency Resistance-Capacitance Oscillators—G. W. Holbrook. (*Electronic Eng.*, vol. 25, pp. 509–511; Dec., 1953.) The relative merits of shunt-capacitance and shunt-resistance oscillators are discussed. The conditions of oscillation are analysed and the upper frequency limits are examined.

621.373.422/.43 686

Sinusoidal and Relaxation Oscillations sustained by Nonlinear Reactances—R. S. Mackay. (*Jour. Appl. Phys.*, vol. 24, pp. 1163–1167; Sept., 1953.) Descriptions are given of various combinations of nonlinear components (e.g. a saturating choke) with linear components (e.g. a capacitor) whereby negative-resistance characteristics can be obtained either of the type in which current is a single-valued function of voltage, or of the type in which voltage is a single-valued function of current. Practical applications are discussed.

621.373.52.029.4 687

A Transistor M. C. W. Adapter—H. V. Braun. (*QST*, vol. 37, p. 51; Sept., 1953.) A miniature keyed af RC oscillator is described.

621.375.2.024:621.314.58 688

Magnetic-Converter D. C. Amplifier—W. A. Rote. (*Electronics*, vol. 26, pp. 170–173; Dec., 1953.) The dc amplifier described comprises a magnetic second-harmonic converter followed by an ac amplifier. Dc signals with power as low as 2×10^{-15} w can be amplified.

621.375.2.029.4.012.3 689

Audio Nomographs—J. F. Sodaro. (*Electronics*, vol. 26, pp. 200, 202; Dec., 1953.) Charts are presented for designing a pentode af amplifier to have desired gain and bandwidth. The method involves the use of separate equivalent circuits for the upper, middle and lower parts of the frequency band.

621.375.232.4.029.63 690

Disk-Seal-Triode Amplifiers for Decimetre-Wavelength Radio Links—A. Egger and G. Pusch. (*Fernmeldetech. Z.*, vol. 6, pp. 486–490; Oct., 1953.) Amplifiers for increasing the transmitter output power and receiver sensitivity in existing links are considered. Grounded-grid circuits are used; simple formulas are derived for gain and bandwidth, giving values in good agreement with experimental results obtained with Type-EC55 and Type-2039A tubes.

621.375.3 691

Magnetic Amplifier Circuits and Applications—R. A. Ramey. (*Elect. Eng., N. Y.*, vol. 72, pp. 791–795; Sept., 1953.) A chronological survey.

621.375.421:621.314.7 692

The Surface-Barrier Transistor: Part 3—Circuit Applications of Surface-Barrier Transistors—J. B. Angell and F. P. Keiper, Jr. (Proc. I.R.E., vol. 41, pp. 1709–1712; Dec., 1953.) The operating characteristics of the surface-barrier transistor are discussed and two amplifier circuits are described, namely (*a*) a wideband low-pass amplifier, and (*b*) a band-pass amplifier for a center frequency of 30 mc. This type of transistor combines the ability to operate at vhf with the low power consumption of the junction type. Part 2: 896 below.

631.396.6.002.2 693

Mechanized Production of Electronic Equipment—R. L. Henry and C. C. Rayburn. (*Electronics*, vol. 26, pp. 160–164; Dec., 1953.) An illustrated account is given of production methods developed at the National Bureau of Standards, based on modular design. A steatite wafer $\frac{7}{8}$ inch $\times\frac{7}{8}$ inch $\times 1/16$ inch is used as a basic unit on which components are printed or mounted over printed wiring. Six of these wafers are automatically stacked and connected to form a plug-in unit. Automatic silver-painting, tuning, dip-soldering and testing machines are used. For other accounts see *Tech. News Bull. Nat. Bur. Stand.*, vol. 37, pp. 161–170; Nov., 1953, and *Tele-Tech*, vol. 12, pp. 70–72, 136; Nov., 1953.

621.396.6.002.2 694
Automatic Assembly of Electronic Equipment—L. K. Lee and C. Brunetti. (*Elect. Mfg.*, vol. 52, pp. 97–109, 308; July, 1953.) Description of a complete production line for a radar chassis; attaching machines place components on a printed-circuit base plate.

621.396.6.002.2:621.357:621.315 695
A Flexible Plated Circuit—E. R. Bowerman and R. F. Walton. (*Radio & Telev. News, Radio-Electronic Eng. Section*, vol. 50, pp. 12–13; Sept., 1953.) The "wiring," initially formed as a 0.001–0.003-inch thick, Cu electrodeposit on a stainless steel plate, is stripped off on a cloth-backed adhesive tape. The complete manufacturing process is described.

GENERAL PHYSICS

537.52 696
The Ignition Mechanism of an Electric Gas Discharge in a Transverse Magnetic Field at Pressures of $10^{-1}-10^{-8}$ Torr—R. Haefer. (*Acta Phys. Austriaca*, vol. 7, pp. 251–277; July, 1953.) Continuation of work noted in 112 of January. A nonuniform field is obtained by making the radius of the outer cylinder much greater than that of the inner. The ignition characteristic (ignition-voltage/magnetic-induction × electrode separation) obtained by calculation is compared with measurements in Ar; the agreement is good. The ionization coefficient is independent of pressure and the electron replacement coefficient is proportional to pressure. With high voltages and low magnetic fields the electrons are produced mainly by ionic bombardment of the outer cylinder and by ion collisions in the gas; with low voltages and high magnetic fields the electrons are produced mainly by ionic bombardment of the end surfaces. A formula relating the electron replacement coefficient to the ratio between the mean free path and the parameter of the cycloidal electron trajectory gives results in good agreement with those derived from the observed ignition characteristics.

537.52+523.72]:621.383 697
Study of High-Frequency Fluctuations from Light Sources using Phototubes and Tuned Radio-Frequency Amplifiers—K. Landecker and B. J. Robinson. (*Proc. Phys. Soc.*, vol. 66, pp. 737–742; Sept. 1, 1953.) Observations have been made at frequencies up to 95 mc, using two different amplifiers for the ranges below and above 25 mc; the methods of connecting the photocell (R.C.A. Type 919) to the amplifiers are described. The spatial distribution of some types of oscillation along the axis of vapour discharges was investigated. Attempts to observe fluctuations of light from the sun have been made only during "quiet" periods and have so far yielded negative results.

537.521.7 698
Calculation of the Behaviour of Sparks with Resistance and Self-Inductance in the Circuit—W. Weizel. (*Z. Phys.*, vol. 135, pp. 639–657; Sept. 25, 1953.)

537.521.7:681.142 699
Analogue-Computer Solution of the Differential Equation for a Spark Gap—A. Walther and K. J. Lesemann. (*Z. Phys.*, vol. 135, pp. 658–664; Sept. 25, 1953.) The differential equation derived by Weizel (698 above) is easily solved by means of the I.P.M.-Ott integrator.

537.533.8 700
Neutralization of Ions and Ionization of Atoms near Metal Surfaces—L. J. Varnerin, Jr. (*Phys. Rev.*, vol. 91, pp. 859–863; Aug. 15, 1953.) When an ion or an atom approaches a metal surface, neutralization or ionization processes are often possible. The Franck-Condon principle is applied in the determination of the probability of electron transfers. Such transfers are limited to definite ranges of separation from the surface. Most secondary-electron emission is due to an Auger-type process, the contribution due to de-excitation of metastable atoms being very small.

537.56 701
Ionization Phenomena in Gases—A. von Engel and G. Francis. (*Nature* (*London*), vol. 172, pp. 798–799; Oct. 31, 1953.) A brief summary of papers presented at the conference held in Oxford in July 1953. The subjects discussed included the spark, arc, glow and hf discharges, G-M counters and fundamental processes.

537.562 702
Theory of Ionized Media with Distant Boundaries—M. Hoyaux. (*Rev. gén. Élect.*, vol. 62, pp. 421–438; Sept., 1953.) Continuation of work noted in 381 of 1952. The theory is developed for a configuration in which the electrodes are relatively close while the boundaries are relatively distant. Experimental results confirm the theory. The solution of the differential equations involved, and summarized theory of the potential distribution in the mercury-vapor-rectifier arc are given in appendices.

537.564 703
Ionization of Gas by Electrons—J. K. Knipp, T. Eguchi, M. Ohta, and S. Nagata. (*Prog. Theor. Phys., Osaka*, vol. 10, pp. 24–30; July, 1953.) A statistical analysis is made of the ionization produced by an electron when it is absorbed in hydrogen. Linear integral equations are obtained for the average number and the mean-square fluctuation of the ion pairs. These are evaluated approximately for high values of incident energy.

538.52:537.311.5:621.396.677.8 704
On the Current Induced in a Conducting Ribbon by a Current Filament Parallel to It—E. B. Moullin. (*Proc. IEE*, part III, vol. 100, pp. 379–381; Nov., 1953.) Digest only. The discussion presented makes use of results obtained previously [2723 of 1952 (Moullin and Phillips)] and constitutes one stage in the determination of the diffraction pattern obtained with a system of aerials in the presence of a metal reflector of arbitrary size and shape.

538.56.029.66:061.3 705
Microwave Optics—E. Wolf. (*Nature* (*London*), vol. 172, pp. 615–616; Oct. 3, 1953.) Account of a symposium held at McGill University, Montreal, June, 1953.

538.566:535.42/.43 706
Solution of Electromagnetic Scattering Problems as Power Series in the Ratio (Dimension of Scatterer)/Wavelength—A. F. Stevenson. (*Jour. Appl. Phys.*, vol. 24, pp. 1134–1142; Sept., 1953.) The calculation of the successive terms in the series expressing the scattered field requires only the solution of standard problems in potential theory, together with the evaluation of certain potential integrals. The series can be calculated as far as desired if Laplace's equation can be solved, but the calculation is increasingly complex for successive terms. The special case of scattering by a perfect conductor is also considered and its relation to the problem of diffraction by an aperture in a conducting screen is indicated. Expressions for the distant field are derived.

538.566:535.42/.43 707
Electromagnetic Scattering by an Ellipsoid in the Third Approximation—A. F. Stevenson. (*Jour. Appl. Phys.*, vol. 24, pp. 1143–1151; Sept., 1953.) The method described in 706 above is used to evaluate the first three terms of the power series in k ($=2\pi\lambda$), viz. those in k^2, k^3 and k^4; the term in k^3 vanishes because of the symmetry of the scattering body. The result is expressed as the sum of two elliptic integrals, which are functions of the three principal axes of the ellipsoid. The special cases of the spheroid, perfectly conducting ellipsoid, perfectly conducting disk and of diffraction by an elliptical or circular hole in a perfectly conducting screen are considered.

538.566:535.42 708
The Vector Wave Function Solution of the Diffraction of Electromagnetic Waves by Circular Disks and Apertures: Part 1—Oblate Spheroidal Vector Wave Functions. Part 2—The Diffraction Problems—C. Flammer. (*Jour. Appl. Phys.*, vol. 24, pp. 1218–1231; Sept., 1953.) The vector wave functions considered are the solenoidal solutions of the vector Helmholtz equation. Oblate spheroidal vector wave functions are defined and the expansions for plane polarized waves in terms of them are obtained. A unique solution is obtained for the diffraction by an infinitely thin, perfectly conducting circular disk and by a circular aperture in a plane conducting screen. Two separate groups of these functions are combined to fulfil the condition $E_\phi=0$ at the rims of the aperture and disk, using the spheroidal coordinate system ϵ, ξ, ϕ.

538.566:535.42 709
Diffraction of Electromagnetic Waves by an Aperture in a Large Screen—G. Bekefi. (*Jour. Appl. Phys.*, vol. 24, pp. 1123–1130; Sept., 1953.) The approximate solution of the three-dimensional diffraction problem is obtained by using a single component of the Hertz vector. The results are applied to the calculation of the field in the plane of a circular aperture which is large compared with the wavelength. Experiments confirm some of the theoretical results.

538.566:535.42 710
Diffraction of Electromagnetic Waves by Two Parallel Half-Planes—B. N. Harden. (*Proc. IEE*, part III, vol. 100, pp. 348–350; Nov., 1953.) The field of a plane wave diffracted by the edges of two parallel conducting sheets has been measured close to the diffracting edges for various spacings between the sheets. Experimental results for a spacing of one wavelength are compared with values derived from theory presented by Clemmow (1620 of 1951); the agreement is satisfactory.

537.5 711
Electronic and Ionic Impact Phenomena [Book Review]—H. S. W. Massey and E. H. S. Burhop. Publishers: Clarendon Press, Oxford, 1952, 699 pp., 70 s. (*Proc. Phys. Soc.*, vol. 66, pp. 851–853; Sept. 1, 1953.) ". . . this work is likely to be the standard reference book on the subject for some time to come."

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.5:621.396.969.3 712
The Radio Echo from the Head of Meteor Trails—I. C. Browne and T. R. Kaiser. (*Jour. Atmos. Terr. Phys.*, vol. 4, pp. 1–4; Sept., 1953.) Calculations based on diffraction theory give values for the intensity of head echoes in agreement with observation, and also indicate that the ratio between the intensity of the head echo and that of a specularly reflected body echo should be proportional to the radio wavelength and inversely proportional to the difference in range between these echoes. Other anomalous meteor echoes may arise from discontinuities associated with visual flares.

523.53:621.396.96 713
Radar Determination of the Height of Disappearence of Meteor Trails of Known Radiant

P. Volmer. (*Compt. Rend. Acad. Sci.* (*Paris*), vol. 237, pp. 1065–1067; Nov. 2, 1953.) Observations were made during the period August 11–13, 1952 at Meudon, using radar equipment operating on a wavelength of 4 m with a peak power of about 100 kw. Curves representing the time variation of the distance of the theoretically nearest reflection point for various values of the height h at which the trails disappear are shown together with observed nearest reflection points. From the comparison it is deduced that the mean value of h is about 85 km.

523.72+523.85]:621.396.822 714

A Symposium on Radio-Astronomy at Jodrell Bank—R. H. Brown. (*Observatory*, vol. 73, pp. 185–198; Oct., 1953.) Account of the proceedings at the symposium held in July, 1953.

523.72:621.396.822 715

The Distribution of Radio Brightness over the Solar Disk at a Wavelength of 21 Centimetres: Part 2—The Quiet Sun—One-Dimensional Observations—W. N. Christiansen and J. A. Warburton. (*Aust. Jour. Phys.*, vol. 6, pp. 262–271; Sept., 1953.) Assuming the distribution over the solar disk to be circularly symmetrical at this wavelength, the derived radial brightness distribution shows marked limb-brightening. The observed distribution of brightness is in fair agreement with the calculations made from solar models involving a 10^4 degrees K chromosphere and $0.3–3.0\times10^6$ degrees K corona, provided that the coronal densities lie between 0.5 and 1.0 times the values usually quoted. Conclusive evidence of a quiet-level rf emission was obtained. Part 1: 3209 of 1953.

523.72:621.396.822:621.396.621 716

Two U. H. F. Radiometers (160 Mc/s and 9.350 Mc/s) and Some Radio-Astronomy Applications—J. Arsac, E. J. Blum, J. H. Lestel, and J. H. Steinberg. (*Onde élect.*, vol. 33, pp. 527–532; Aug./Sept., 1953.) Details are given of improved radio-noise receiving equipment used for continuing the experiments previously reported [3402 of 1953 (Steinberg)]; a power-supply unit stable to within 1 part in 10^{-4} for mains variations of ±5 per cent, a parabolic-reflector antenna for 9.35 mc, and a dipole aerial array for 160 mc are described. Measurements of the distribution of rf brightness over the sun are reported; these include observations made during the solar eclipses of 1951 and 1952.

523.746 717

Progressive Variation of the Shape of the Sunspot Curves—A. Kiral. (*Naturwissenschaften*, vol. 40, pp. 477–478; Sept., 1953.) Statistical analysis of the sunspot numbers for the 30 eleven-year cycles since 1610 indicates that the asymmetry of the curves is increasing, thus giving support to Gleissberg's theory that there is another cycle with a period of the order of thousands of years.

535.325:551.510.52 718

Measurement of Variations in Atmospheric Refractive Index with an Airborne Microwave Refractometer—H. E. Bussey and G. Birnbaum. (*Jour. Res. Nat. Pur. Stand.*, vol. 51, pp. 171–178; Oct., 1953.) The cavity-resonator refractometer described is essentially the same as that used for previous measurements [2176 of 1951 (Birnbaum)]. Observations were made at heights up to 10,000 feet; examples of strip records obtained are reproduced. The variations were negligible for distances <5 m. Large increases of refractive index were observed on entering cumulus clouds, and intense fluctuations were noted within the clouds.

538.71 719

Airborne Magnetometer for determining All Magnetic Components—E. O. Schonstedt and H. R. Irons. (*Trans. Amer. Geophys. Union*, vol. 34, pp. 363–378; June, 1953.) Description of the vector airborne magnetometer Type-1A, an enlarged and modified form of the instrument previously described by Felch et al. (220 of 1948).

550.38:551.510.535:621.396.11 720

Measurements of the Terrestrial Magnetic Field in the *E*-Layer—M. Cutolo. (*Nature* (*London*), vol. 172, pp. 774–775; Oct. 24, 1953.) Two methods are outlined, both based on determination of the gyrofrequency, which is related by a simple formula to the intensity H of the geomagnetic field in the lower part of the E layer. The first method is based on the double-hump resonance curve (2617 of 1950) and the second is based on the self-demodulation of radio waves at carrier frequencies near gyrofrequency (1758 of 1951). A table is given of values of H determined by these methods in Italy.

550.384 721

A Universal Time Component in Geomagnetic Disturbance—R. P. W. Lewis and D. H. McIntosh, (*Jour. Atmos. Terr. Phys.*, vol. 4, pp. 78–80; Sept., 1953.) Evidence of a universal time component in the diurnal variation of the geomagnetic disturbance is obtained from an analysis of K-index figures.

550.384:621.396.822.029.42 722

Low-Frequency Noise in the Range 0.5–20 c/s—J. Aarons and M. Henissart. (*Nature* (*London*), vol. 172, pp. 682–683; Oct. 10, 1953.) Continuation of previously noted investigations [1628 of 1948 (Menzel and Salisbury) and 3408 of 1948 (Willis)] of the correlation between lf em fluctuations and geomagnetic and solar phenomena. A pickup loop with an effective area of 257 m^2 was used with an amplifier having a gain og 160 db and a recorder with chart speed of 1 mm/s. An operating site with low-noise characteristics was chosen. Evidence was obtained of frequent storms in the noise-frequency range studied. A diurnal variation similar to that of the Cheltenham K indices was observed. Analysis indicates significant correlation between the lf noise and the 200-mc solar noise observed 29 days earlier.

551.510.53:546.214 723

Daily Variation of Amount of Ozone in the Atmosphere—K. R. Ramanathan and B. V. R. Murthy. (*Nature* (*London*), vol. 172, pp. 633–634; Oct. 3, 1953.) Observations made at Mount Abu and Ahmedabad from Nov., 1952 to April, 1953 showed a substantial increase of ozone during night hours, with rapid change-over from day to night values after sunset.

551.510.535 724

An Interpretation of Vertical-Incidence Equivalent-Height versus Time Recordings on 150 kc/s—R. Lindquist. (*Jour. Atmos. Terr. Phys.*, vol. 4, pp. 10–27; Sept., 1953.) The results of observations made in Pennsylvania, U.S.A., between Jan., 1950 and April, 1952 are shown graphically and discussed. One form of echo regularly observed during magnetically disturbed nights is due to one type of sporadic-E stratum. Recorded group and phase heights are compared and the differences compared with those predicted from theory. Results are also given of a preliminary investigation of the effects of solar flares.

551.510.535 725

Investigation of Travelling Disturbances in the Ionosphere by Continuous-Wave Radio—Y. V. Somayajulu, B. R. Rao and E. B. Rao. (*Nature* (*London*), vol. 172, pp. 818–820; Oct. 31, 1953.) Continuous records of the signal intensity of cw transmissions over a 640-km path at 9.59 mc and 4.92 mc indicate an F-layer-disturbance velocity of 200–400 m/s. Transmission modes up to $2\times F$ and $5\times F$, respectively, were observed. Simultaneous signal-intensity records of two in-line transmitters 240 km apart, operating at $\sim$7.5 mc, showed a constant 8.5-minute interval between the corresponding maxima, indicating a disturbance velocity of $\sim$230 m/s.

551.510.535 726

The Effect of Soft X-rays from the Solar Corona on the Formation of the Normal Ionospheric *E* layer—G. Elwert. (*Jour. Atmos. Terr. Phys.*, vol. 4, pp. 68–77; Sept., 1953. In German.) A calculation has been made previously of the soft X-rays from the solar corona (*Z. Naturf.*, vol. 7a, pp. 202–204; 1952.) The results are used to determine the height at which the radiation is absorbed and the number of electrons present at this height under equilibrium conditions. The results agree well with observations of the normal E layer.

551.510.535 727

The Structure of the *F* Region of the Ionosphere—A. A. Weiss. (*Aust. Jour. Phys.*, vol. 6, pp. 291–303; Sept., 1953.) The effects of temperature cycles, of a decay coefficient which is nonuniform with height, and of vertical tidal drifts are considered. The diurnal and seasonal height variations of the F_2 region are explained qualitatively by postulating, in addition to the vertical tides acting on an isothermal Chapman region, a diurnal temperature cycle. This requires a decay coefficient which does not change rapidly with height. On an alternative hypothesis involving discontinuities in the height gradient of the decay coefficient, tidal drifts are still necessary, but a diurnal temperature cycle is not of major importance.

551.510.535 728

World-wide Diurnal Variations in the F_2 Region—C. W. Allen. (*Jour. Atmos. Terr. Phys.*, vol. 4, pp. 53–67; Sept., 1953.) The chief characteristics of the f_2F_2 variations are described in terms of (*a*) the sunspot-minimum anomaly, (*b*) the sunrise anomaly and (*c*) the diurnal-range anomaly. These anomalies are evaluated quantitatively and extracted from the observations to determine the normal curves. The world distribution of these anomalies is studied and explanations are suggested. Variations of $h'F_2$ do not appear to be related either to the sunspot cycle or to the f_0F_2 variations.

551.510.535 729

The Electron Content of the F_2 Layer above Singapore—B. W. Osborne. (*Jour. Atmos. Terr. Phys.*, vol. 4, pp. 82–84; Sept., 1953.) A comparison of the estimated total ionization present in a unit column below the level of maximum ionization density of the F_2 layer in 1949 and in 1952.

551.510.535:550.386 730

Geomagnetic and Ionospheric Relationships—R. P. W. Lewis and D. H. McIntosh. (*Jour. Atmos. Terr. Phys.*, vol. 4 pp. 44–52; Sept., 1953.) The effect of a magnetic "disturbance" on various geomagnetic and ionospheric parameters is investigated by choosing days on which the K_p sum is markedly different from that of the adjacent days. Most of the parameters show a peak or trough corresponding to that of the disturbance, following it with a delay of 0–18 hours. Particular attention is called to some peculiar seasonal effects, to features of the sporadic E layer at Slough and the vertical movement of the F_2 layer at Huancayo.

551.510.535:550.389 731

The Effect of the Magnetic Equator on the Ionization of the E_s Layer—K. Rawer. (*Compt. Rend. Acad. Sci.* (*Paris*), vol. 237, pp. 1102–1104; Nov. 2, 1953.) Observations made at stations at different latitudes in Africa and Europe are analysed. Daytime values of fE_s show a pronounced maximum at the magnetic equator. Observations of the E_s blanketing frequency indicate that the E_s minimum-ionization ceiling is not subject to the effect, which exists only for the ionization clouds.

551.510.535:551.55 732

Winds in the Ionospheric Regions—S. Deb. (*Jour. Atmos. Terr. Phys.*, vol. 4, pp. 28–43; Sept., 1953.) A model for the region between 100 and 400 km height is constructed from considerations of the temperature gradients and the observed wind velocities. According to this model, the wind is south-west in the E and F_1 regions and north-east or east in the F_2 region; its velocity increases from 50 mph at 100 km to 200 mph at 200 km. There is a seasonal variation in the magnitude of the velocity, but the model does not involve any diurnal or seasonal changes of direction such as have been reported by observers.

551.510.535:621.396.11 733

Results relating to the Critical Frequency and the Transmission Factor of the Ionosphere F_1 Layer—Theissen. (*See* 831.)

551.594.5:621.396.11 734

A Note on Auroral Interaction—N. C. Gerson. (*Jour. Atmos. Terr. Phys.*, vol. 4, pp. 81–82; Sept., 1953.) The modulation of a radio wave due to a moving auroral reflecting screen is discussed.

LOCATION AND AIDS TO NAVIGATION

621.396.93 735

H.F. Direction Finding—S. B. Smith and H. G. Hopkins. (*Wireless Eng.*, vol. 31, pp. 11–14; Jan., 1954.) A comparison is made of the error components with (*a*) pulsed transmissions and (*b*) cw transmissions, with particular reference to the performance of Adcock cr direction finders operating at frequencies near 8 mc and in the absence of a ground ray. The results presented refer to transmission distances from about 400 to 2,000 km and indicate that pulse operation will normally be at least as accurate as cw operation; in the most favourable circumstances for pulse operation (i.e. when a direct first-order echo via the E or E_s layer can be used) the expected ratio of pulse variance to cw variance is about 1/3 for single snap bearings.

621.396.93 736

An Analysis of Errors in Long-Range Radio Direction-Finder Systems—J. G. Holbrook. (Proc. I.R.E., vol. 41, pp. 1747–1749; Dec., 1953.) A rigorous mathematical analysis is made of errors usually encountered with a newly installed fixed Adcock df station. The effect of variations in the antenna spacing is discussed particularly.

621.396.96 737

A Theory of Target Glint or Angular Scintillation in Radar Tracking—R. H. Delano. (Proc. I.R.E., vol. 41, pp. 1778–1784; Dec., 1953.) "A theory is presented to describe the statistical aspects of tracking a complex isolated structure, such as an aircraft or naval vessel, by radar. The results are expressible in simplest form when the target subtends an angle small compared with the beamwidth. Other situations require special consideration and treatment, but can be attacked by the same general methods. However, when the angle subtended by the target is small, a single description applies to all radar tracking systems. An apparent and an effective radar center are defined and their statistical properties derived. Special treatment is given to additional noise arising in conical scanning due to amplitude fluctuations as such. The theory provides information relating to the spectra as well as to the probability densities and r.m.s. values of the pertinent quantities. It must be understood that the theory is approximate, is based on a particular model of the target, and leaves the determination of certain critical parameters to experiment in the case of any particular target."

621.396.96 738

The Effective Number of Pulses per Beamwidth for a Scanning Radar—L. V. Blake. (Proc. I.R.E., vol. 41, p. 1785; Dec., 1953.) Addendum to paper noted in 2671 of 1953.

621.396.96:551.578 739

Radar Displays of Atmospheric Precipitation—B. Birardi. (*Alta Frequenza*, vol. 22, pp. 146–160; June/Aug., 1953.) Theory of the reflection of radio waves by precipitation is presented and an illustrated description is given of results obtained at the Research Centre for Microwave Physics at Florence. The future research program is outlined.

621.396.96:621.39.011.11 740

Radar Detection and Information Theory—U. Tiberio. (*Alta Frequenza*, vol. 22, pp. 161–183; June/Aug., 1953.) Radar operation is analysed by a statistical method; errors in range and direction are considered. The common ground between the theory of radar and communication is demonstrated by a discussion of automatic and Doppler-effect radar systems.

621.396.962.3:621.396.812.3 741

Interpretation of the Fluctuating Echo from Randomly Distributed Scatterers: Part 1—J. S. Marshall and W. Hitschfeld. (*Canad. Jour. Phys.* vol. 31, pp. 962–994; Sept., 1953.) The random fluctuations in the radar echo are investigated statistically and by analogue computation. The results are interpreted in terms of physical methods of reducing their effect. Thus, continuous averaging and limited averaging by the receiver or the A-scope display tube (superposition of traces) is considered. The precision and the method of measurement of the intensity of the echo from steady and moving targets against a fluctuating noise background are also discussed.

621.396.962.3:621.396.812.3:551.578 742

Interpretation of the Fluctuating Echo from Randomly Distributed Scatterers: Part 2—P. R. Wallace. (*Canad. Jour. Phys.*, vol. 31, pp. 995–1009; Sept., 1953.) Echoes from atmospheric precipitation are considered. The method of averaging independent signals is compared with that of continuous averaging. With frequency variation, effectively independent observations from a given region can be obtained. The variation of the signal as the reflection region recedes continuously or as the beam sweeps laterally, is studied. The Markoff method is used throughout. Part 1: 741 above.

621.396.963.3 743

Information Cells on Intensity-Modulated C.R.T. Screens—D. Levine. (Proc. I.R.E., vol. 41, pp. 1766–1768; Dec., 1953.) Analysis of screen excitation is based on the assumption that the distribution of the electrons across the beam is Gaussian. It is assumed that two identical radar pulses are just resolvable when they are spaced on the screen so that the crossover of their charge distributions occurs at 40 per cent of the peak intensity; the distance between the 40 per cent points defines the size of the "information cell." A specific number of information cells is associated with each type of cr tube for a given pulse length and maximum beam current.

621.396.963.8 744

Passive Radar Responder—L. de Magondeaux and R. de Magondeaux. (*Onde élect.*, vol. 33, pp. 533–539; Aug./Sept., 1953.) The arrangement described consists essentially of a resonator associated with a crystal which, when excited by incident pulses of radiation at a resonance frequency, re-radiates between these pulses the energy abstracted from them. In its simplest form the resonator comprises a $\lambda/2$ dipole with the crystal at its midpoint. Using a quartz crystal with a fundamental frequency of 40 mc, the highest practical operating frequency is the overtone at 200 mc. Possible applications are discussed under three headings, namely (*a*) those based on the individual character of the response, (*b*) those making use of the time delay of the response, and (*c*) those involving modulation of the response.

621.369.969.11 745

Doppler-Effect Omnirange—P. G. Hansel. (Proc. I.R.E., vol. 41, pp. 1750–1756; Dec., 1953.) An omnirange is described in which the transmitting aerial is caused either to move or to appear to move along a circular path, thus producing low-deviation fm by Doppler effect. Deviation expansion and selective degeneration in an afc circuit are used at the receiver to detect the directional signal in the presence of fm noise. Advantages claimed for the system include improved resolution, accuracy and ease of multiplexing.

MATERIALS AND SUBSIDIARY TECHNIQUES

531.787.6/.7 746

High-Resolution Micromanometer—(*Tech. News Bull. Nat. Bur. Stand.*, vol. 37, pp. 140–142; Sept., 1953.) An instrument designed by Perls, Kaechale, and Goalwin, and capable of measuring differential pressures down to 0.03μ of Hg, uses a capacitance-type pickup with a thin diaphragm and a capacitance bridge driven by a 500-kc oscillator.

533.56 747

A Portable High-Vacuum System—V. C. DeMaria. (*Sylvania Technologist*, vol. 6, pp. 96–97; Oct., 1953.) Outline description of a portable diffusion pump suitable for maintaining pressures down to $\sim 10^{-6}$ mm Hg.

535.215.3:538.639:546.289 748

Photoelectromagnetic and Photodiffusion Effects in Germanium—T. S. Moss, L. Pincherle, and A. M. Woodward. (*Proc. Phys. Soc.*, vol. 66, pp. 743–752; Sept. 1, 1953.) When a slab of Ge is illuminated, a potential gradient is created in the direction of illumination, due to the difference between the electron and hole mobilities (photodiffusion effect). If a magnetic field is applied perpendicular to the direction of illumination, a potential gradient is created in the direction perpendicular to both field and illumination (photoelectromagnetic effect); voltages as great as 0.5 v have been obtained. The saturation value of the photoelectromagnetic voltage provides a convenient measure of the surface recombination velocity. Theory and experimental details are given.

535.37 749

Studies on the Concept of Large Activator Centers in Crystal Phosphors—J. Ewles and N. Lee. (*Jour. Electrochem. Soc.*, vol. 100, pp. 392–407; Sept., 1953.) A study in three parts, under the headings (*a*) dependence of luminescent efficiency on concentration of activator; size of luminescent centres; (*b*) effects of concentration of activator, of temperature, and of flux on the excitation and emission of CaO:Bi phosphors; (*c*) preparation and properties of CaO phosphors with eleven different activators.

535.37 750

The Luminescence of Alkaline-Earth Polysulphides—H. Gobrecht and D. Hahn. (*Z. Phys.*, vol. 135, pp. 523–530; Sept. 25, 1953.)

537.226:546.431.82 751

The Dielectric Properties of Barium-Titanate Single Crystals in the Region of their Upper Transition Temperature—L. E. Cross. (*Phil. Mag.*, vol. 44, pp. 1161–1170; Oct., 1953.) A determination was made of the ferroelectric hysteresis and the dielectric constant over the temperature range 20 degrees C–150 degrees C.

The ferroelectric transition in untwinned crystals, at ~120 degrees C, is a thermodynamically first order transition; in twinned crystals different regions transform at different temperatures. In untwinned crystals hysteresis is reintroduced at temperatures in a small range above the transition temperature by application of a sufficient electric field. The forms of the hysteresis figures are explained in terms of Devonshire's theory (663 of 1950).

537.226.2:537.29:621.315.616 752

Variations of the Dielectric Constant of Some Plastics as a Function of the Electric Field—G. Mesnard and L. Eyraud. (*Compt. Rend. Acad. Sci.*, (*Paris*), vol. 237, pp. 1406–1407; Nov. 30, 1953.) Measurements made using a double-heterodyne method are outlined; the material under test constituted the dielectric of a capacitor in a Hartley oscillator circuit, and was subjected to a unidirectional electric field of variable strength. Relative variations of the order of 5×10^{-6} in the value of the dielectric constant could be detected. Results obtained with vinyl chloride, polyethylene, cellophane and other plastics are reported.

537.311.33 753

A More Exact Treatment of the Equations describing Dielectric Relaxation and Carrier Motion in Semiconductors—J. Keilson. (*Jour. Appl. Phys.*, vol. 24, pp. 1198–1200; Sept., 1953.) An exact treatment of the linearized equations of hole and electron flow in a homogeneous semiconductor leads to an expression for the polarization attributable to local variations is conductivity. The corrections to the previously obtained values for the effective mobility and the diffusion coefficient are of the order of τ_r/τ where τ_r is the relaxation time and τ is the lifetime. These corrections are negligible for semiconductors.

537.311.33:546.281.26 754

The Infrared Absorption Spectrum of Silicon Carbide—A. K. Ramdas. (*Proc. Indian Acad. Sci. A.*, vol. 37, pp. 571–577; April, 1953.) The transmission spectra of 12 specimens were studied over the range 1–20μ. The results are discussed in relation to X-ray determinations of the structure.

537.311.33:546.289 755

Thermal Acceptors in Vacuum-Heat-Treated Germanium—S. Mayburg and L. Rotondi. (*Phys. Rev.*, vol. 91, pp. 1015–1016; Aug. 15, 1953.) The Ge single-crystal specimen was heated by passing a current directly through it, and was cooled by radiation. The value found for the concentration of acceptors differed by as much as a factor of 80 from results reported by workers using other methods of vacuum heat treatment. Reasons are advanced for concluding that the observed acceptors are lattice vacancies and not impurity atoms.

537.311.33:546.289 756

Infrared Absorption of *p*-type Germanium—W. Kaiser, R. C. Collins and H. Y. Fan. (*Naturwissenschaften*, vol. 40, p. 479; Sept., 1953.) Measurements were made over the wavelength range 1.5–35μ, using specimens with resistivities from 0.04 to about 10Ω cm. The characteristic absorption spectrum obtained at room temperature is much more complex than for *n*-type Ge. Weak absorption bands were found at about 2.9μ and 4.5μ, and a strong wide band centred at about 20μ. Modified curves obtained at 5 degrees and 77 degrees K are also shown and discussed.

537.311.33:546.824–31 757

Electrical Properties of Titanium Dioxide Semiconductors—R. G. Breckenridge and W. R. Hosler. (*Phys. Rev.*, vol. 91, pp. 793–802; Aug. 15, 1953.) Measurements of resistivity and Hall coefficient in the temperature range −190 degrees C to +500 degrees C were made on ceramic and single-crystal rutile specimens with resistivities between 0.1 and 100Ω cm. From these measurements, which were made for two different crystal orientations, the variations of electron mobility and charge-carrier concentration with temperature were deduced. The mobility data can be explained in terms of scattering, with the effect of lattice vibration predominant at high temperatures, and that of ionized impurities predominant at lower temperatures. A large effective electron mass is deduced from the mobility values, indicating that the specimens were not degenerate in the temperature range studied, in spite of the large number of charge carriers. The charge-concentration variation found suggests that two types of donor centres, possibly oxygen ion vacancies, are present.

537.311.33:548.55:546.682.86 758

Hall Effect and Conductivity of InSb Single Crystals—M. Tanenbaum and J. P. Maita. (*Phys. Rev.*, vol. 91, pp. 1009–1010; Aug. 15, 1953.) Measurements on three samples over a range of temperatures are reported, a reversal in sign of the Hall coefficient occurring in two cases, at 155 degrees and 182 degrees K respectively. The deduced value of the energy gap at room temperature is 0.18 ev; this is in agreement with that obtained from infrared-absorption measurements.

537.311.33:621.314.7 759

The Surface-Barrier Transistor: Part 5—The Properties of Metal-to-Semiconductor Contacts—Schwarz and Walsh. (*See* 895.)

537.312.8 760

Galvano-Magnetic Effects at High Frequencies—B. Donovan and E. H. Sondheimer. (*Proc. Phys. Soc.*, vol. 66, pp. 849–851; Sept. 1, 1953.) A theoretical investigation of the variation of resistivity of a semi-infinite metal with the frequency of an electric field parallel to the surface, in the presence of a magnetic field perpendicular to the surface.

537.533:546.78 761

Crystallographic Variations of Field Emission from Tungsten—M. K. Wilkinson. (*Jour. Appl. Phys.*, vol. 24, pp. 1203–1209; Sept., 1953.) Emission from a tungsten single crystal was investigated photometrically at pressures around 10^{-12} mm Hg. The experimental method and, in particular, the vacuum technique, are described and the results are tabulated and shown graphically.

537.533.8:537.311.33 762

Secondary Electron Emission from Impurity Semiconductors—H. Gobrecht and F. Speer. (*Z. Phys.*, vol. 135, pp. 602–614; Sept. 25, 1953.) Measurements were made on four Ge crystals with different impurities and electrical properties. A monotonic increase up to 7 per cent in the secondary-emission factor was observed to accompany an increase up to 1.5×10^3 in conductivity. This increase is attributed to the increase of impurity concentration accompanying the increased conductivity. The decrease in secondary emission, to be expected as a result of the increased number of charge carriers, is masked. The type of conduction and the nature of the impurity do not affect the secondary emission. Measurements made on Ge and Se evaporated layers with and without impurities confirmed the above results. Secondary-emission curves were also obtained for evaporated layers of the four impurity metals used, namely Ga, Sb, Tl and Bi.

538.221 763

On the Nature of Ferromagnetism in Pyrhotite—K. Alexopoulos and A. Theodossiou. (*Proc. Phys. Soc.*, vol. 66, pp. 753–759; Sept. 1, 1953.)

538.221 764

A Study of Bitter Figures on the (110) Plane of a Single Crystal of Nickel—L. F. Bates and G. W. Wilson. (*Proc. Phys. Soc.*, vol. 66, pp. 819–822; Sept. 1, 1953.)

538.221 765

A Proposed Structure for Certain Domain Configurations on a Single Crystal of Nickel—G. W. Wilson. (*Proc. Phys. Soc.*, vol. 66, pp. 840–841; Sept. 1, 1953.)

538.221 766

Microwave Resonance Absorption in some Ferromagnetic Manganese Compounds—G. D. Adam and K. J. Standley. (*Proc. Phys. Soc.*, vol. 66, pp. 823–835; Sept. 1, 1953.)

538.221 767

Magnetic Viscosity in Platinum Cobalt—A. W. Simpson and R. H. Tredgold. (*Proc. Phys. Soc.*, vol. 66, pp. 805–807; Sept. 1, 1953.) Experimental results indicate that this alloy obeys the general relation for ferromagnetic materials found by Barbier (1661 of 1950).

538.221 768

Magnets and Magnetism—Recent Developments—W. Sucksmith. (*Brit. Jour. Appl. Phys.*, vol. 4, pp. 257–262; Sept., 1953.) Ferromagnetic materials, including oxides, are discussed.

538.221 769

Measurement of Permeability Tensor in Ferrites—J. O. Artman and P. E. Tannenwald. (*Phys. Rev.*, vol. 91, pp. 1014–1015; Aug. 15, 1953.) Preliminary report on an experimental method of determining the off-diagonal tensor components of permeability which involves the splitting of degenerate cavity modes in a magnetic field.

538.221 770

A Comparison of the Powder Patterns on a Sample of Grain-Orientated Silicon-Iron with those obtained on a Single Crystal—L. F. Bates and A. Hart. (*Proc. Phys. Soc.*, vol. 66, pp. 813–818; Sept. 1, 1953.)

538.221 771

The Permeability of Silicon-Iron—E. Both. (*Elect. Eng.*, vol. 72, p. 797; Sept., 1953.) Digest only. The Si/Fe alloy described has an initial permeability of 1500 and an incremental permeability value ~0.5 per cent per millioersted; the corresponding values for Ni/Fe alloys are 2000 and 0.2 per cent.

538.247:621.318.2 772

Investigations of Aging Processes in Permanent Magnets—K. J. Kronenberg. (*Z. angew. Phys.*, vol. 5, pp. 321–329; Sept., 1953.) The changes in remanence due to the application of direct and alternating magnetic fields and a variation in the form factor by short-circuiting with a soft iron bar, were investigated experimentally and the results are presented graphically. The magnets investigated were made of tungsten steels, cast and sintered alnic, alnico and iron dust. The remanence of alnic alloys, the most stable magnets, decreased with increase in the number of demagnetizations and with increase in the storage time in the magnetized state. An increase in remanence with storage times was observed in certain cases.

539.23:546.87:535.215.1 773

The Photoelectric Effect of Thin Bi Films—D. J. Fourie. (*Phys. Rev.*, vol. 91, p. 803; Aug. 15, 1953.) The variation of photoelectric current observed when dc is passed through the film depends on the direction and magnitude of the current but is not a pure heating effect since the passage of ac does not cause the same variation.

539.23:546.46–31:537.533.8 774

The Mechanism of Self-Sustained Electron Emission from Magnesium Oxide—D. Dobischek, H. Jacobs, and J. Freely. (*Phys. Rev.*, vol. 91, pp. 804–812; Aug. 15, 1953.) Continuation of work reported in 998 of 1953 (Jacobs et al.). When higher fields are applied, the secondary-emission current becomes very much larger and increasingly independent of the bombarding current, and, under certain conditions, persists for many hours after the bombarding current has been switched off. This enhanced emission has two components. The first is a true field-enhanced secondary-emission effect similar to that previously described. The second component is a self-sustained electron emission produced by the same type of avalanche effect, except that the internal ionization of the dielectric is initiated by electrons produced from within the material.

546.26 775

The Formation of Black Carbon—R. O. Grisdale. (*Jour. Appl. Phys.*, vol. 24, pp. 1082–1091; Sept., 1953.) Electron-microscope evidence is presented in support of the hypothesis that black carbon resulting from pyrolysis of gaseous hydrocarbons is produced through the intermediate formation of droplets of complex hydrocarbons. It appears that the process is fundamentally similar to that for obtaining carbon by the carbonization of solids.

546.321.85:537.226 776

The Properties of Colloidal Ferroelectric Materials: Part 1—Potassium Phosphate (KH_2PO_4)—C. Jaccard, W. Känzig, and M. Peter. (*Helv. Phys. Acta*, vol. 26, pp. 521–544; Sept. 15, 1953. In German.) An isolated and nonconducting ferroelectric crystal of approximately spherical shape cannot become polarized spontaneously, if forced to form a single domain, since the energy of the surface charges would exceed the polarization energy. For small crystals, the wall energy prevents splitting into domains; hence a critical size exists, below which spontaneous polarization cannot occur. This was observed in KH_2PO_4 crystals of diameter <1500 Å embedded in insulating media of dielectric constant $\epsilon \leqq 5$; crystals of diameter >4000 Å showed normal ferroelectric properties. The critical diameter decreases with increasing ϵ; in a conducting medium even 500 Å crystals showed normal spontaneous polarization. The anomaly in the dielectric constant of crystals smaller than the critical size at 1.0 ± 0.5 degrees C below the Curie temperature, is probably not due to an antiferroelectric transition.

546.817.231:537.312.5 777

"Phosphorescent" Effect in Lead Selenide—P. A. Lee. (*Canad. Jour. Phys.*, vol. 31, pp. 1023–1024; Sept., 1953.) Brief report of measurements of the conductivity of a thin layer of PbSe on illumination, at 90 degrees K by tungsten light. The effect observed is similar to that noted in PbS by Chasmar and Gibson (3156 of 1951).

621.314.634.012.6 778

Contribution to the Knowledge of Dynamic Phenomena in the Selenium Rectifier—H. Lauckner. (*Z. angew. Phys.*, vol. 5, pp. 341–349; Sept., 1953.) Current creep was investigated experimentally in Se rectifiers with, and without, a lacquer intermediate layer. The results are in agreement with the mobile charge-carrier hypothesis on the assumption that small field changes due to slow ion movements result in large inverse-current changes. The rapid current response to a step voltage in the lacquer-layer type is due to the inhibition of ion movement at the Se grain boundaries.

621.315.6 779

Recent Progress in Dielectrics—(*Nature*, (*London*), vol. 172, pp. 563–564; Sept. 26, 1953.) Brief account of the discussions at the meeting of the British Association, Section A, in Liverpool, Sept., 1953.

621.315.61.029.4/.53 780

Maxwell-Wagner Loss and Absorption Currents in Dielectrics—B. V. Hamon. (*Aust. Jour. Phys.*, vol. 6, pp. 304–315; Sept., 1953.) The dielectric loss factor of mixtures consisting of a nonpolar base material and a small amount of a slightly conducting solid or liquid "impurity," was measured at frequencies up to 3 mc. "Impurities" in the form of small spheres and in the form of a fine powder covering the surfaces of the grains of the base material were studied. The effect of direct and alternating potential gradients on the conductivity and loss factor of the mixtures was also investigated. The results are shown graphically, compared with theoretical results and with published data for practical dielectrics.

621.315.611 781

Experimental Contribution to the Study of the Dielectric Strength of Solid Insulators—P. Dubois and R. Hérou. (*Rev. Gén. Élect.*, vol. 62, pp. 438–441; Sept., 1953.) Report of experiments carried out at the Laboratoire central des Industries électriques to determine the influence of electrode shape and insulator thickness.

621.315.612 782

Phase Transitions in Antiferroelectric $PbHfO_3$.—G. Shirane and R. Pepinsky. (*Phys. Rev.*, vol. 91, pp. 812–815; Aug. 15, 1953.) $PbHfO_3$ is antiferroelectric below 163 degrees C. and has an intermediate phase between 163 degrees C. and 215 degrees C. which is also antiferroelectric, with a different type of dipole arrangement from that of the lowest phase. At 215 degrees C. $PbHfO_3$ becomes paraelectric, and its structure changes from the tetragona to the cubic type.

621.315.612.4:621.317.733 783

Some Dielectric Properties of Barium-Strontium Titanate Ceramics at 3000 Mcls—L. Davis, Jr. and L. G. Rubin. (*Jour. Appl. Phys.*, vol. 24, pp. 1194–1197; Sept., 1953.) Measurements at 10 kc, 500 kc and 3 kmc indicate that the dielectric constant is independent of frequency at temperatures above the Curie temperature. The effects of electric field strength and temperature on the dielectric constant and the loss tangent were also investigated. The results are shown graphically. The 3-kmc bridge is described.

621.315.613.1 784

Synthetic Mica Investigations: Part 1—A Hot-Pressed Machinable Ceramic Dielectric—J. E. Comeforo, R. A. Hatch, R. A. Humphrey, and W. Eitel. (*Jour. Amer. Ceram. Soc.*, vol. 36, pp. 286–294; Sept. 1, 1953.) The properties and the manufacture of a new ceramic composed entirely of synthetic fluorine-mica are described. Extensive ionic-replacement possibilities permit a large range of variation in the properties, and tables and graphs for the electrical and mechanical characteristics of several types are given. Thus, $BaMg_3Al_2SI_3O_{10}F_2$ has a water absorption <0.1 per cent, density 3.51 g. cm^{-3}, power factor 0.0003, dielectric constant 7.6 and loss factor 0.0022 at 1 mc. The effect of an increase of temperature up to 250 degrees C is small. The transverse strength is >8000 db/in^2.

621.315.616 785

Dielectric Properties of Teflon from Room Temperature to 314 degrees C. and from Frequencies of 10^2 to 10^5 c/s—P. Ehrlich. (*Jour. Res. Nat. Bur. Stand.*, vol. 51, pp. 185–188; Oct., 1953.) Measurements indicate that the dielectric constant decreases slightly with increasing temperature and is independent of frequency at all temperatures.

621.318.22 786

The Coercive Force of Magnets moulded from Very Fine Co-Fe Powders—F. Lihl. (*Acta Phys. austriaca*, vol. 7, pp. 239–247; July, 1953.) Continuation of work noted previously (1935 of 1952). Coercive force, remanence and *BH* product increase with Co content; the practically attainable optimum values are not yet reached for 36.4 per cent Co. The positions of the maxima of coercive force and *BH* product, with respect to variations of reduction time and degree depend on the composition; for a given composition the positions of these maxima depend on the powder preparation and moulding processes. Extrapolation to the case of infinitely low density gives lower values of the coercive force than would be expected from Néel's theory, but indicates the highest practically attainable values.

621.791:546.621 787

Joining Aluminum to Other Materials—M. A. Miller. (*Mater. and Meth.*, vol. 38, pp. 96–99; Sept., 1953.) Methods appropriate to various materials, component designs and service requirements are described.

621.92:549.514.51:621.372.412 788

The Production of Very Thin Quartz Oscillator Plates—J. E. Thwaites and C. F. Sayers. (*B.O. Elect. Eng. Jour.*, vol. 46, part 3, pp. 105–107; Oct., 1953.) Account of the construction and operation of a machine for lapping plates to a thickness of about 0.055 mm.

666.1 789

Glass in the Electronic Industry—M. Manners. (*Electronic Eng.*, vol. 25, pp. 512–516; Dec., 1953.) The various types of glass available are reviewed and their particular applications indicated, with special reference to problems of sealing. Tables show the composition and properties of some of the most common glasses and some combinations of glass and metal for making seals.

MATHEMATICS

511:53:621.39 790

Radio Technology and the Theory of Numbers—B. van der Pol. (*Jour. Franklin Inst.*, vol. 256, p. 265; Sept., 1953.) Correction to paper noted in 3346 of 1953.

513.761.22:621.372 791

Geometric Construction of the Homographic Transformation—P. Mourmant. (*Onde élect.*, vol. 33, pp. 540–542; Aug./Sept., 1953.) A discussion of the geometric properties of the homographic transformation $Z=\alpha(\beta+z)/(\Gamma+z)$, giving generalized impedance in terms of the complex coefficients α, β and Γ and elementary impedance z.

517.6 792

Evaluation of the Integral $\int_0 e^{-u^2-x/u}du$—M. Abramowitz. (*Jour. Math. Phys.*, vol. 32, pp. 188–192; July/Oct., 1953.) The integral studied appears in various physical problems involving particles with Maxwellian distribution of velocities.

518.2:517.564 793

Radix Table for Obtaining Hyperbolic and Inverse Hyperbolic Functions to Many Places—H. E. Salzer. (*Jour. Math. Phys.*, vol. 32, pp. 197–202; July/Oct., 1953.)

MEASUREMENTS AND TEST GEAR

53.08:621.39.001.11 794

The Negentropy Principle of Information—L. Brillouin. (*Jour. Appl. Phys.*, vol. 24, pp. 1152–1163; Sept., 1953.) The statistical definition of information is compared with Boltzmann's formula for entropy. The relations between the information obtained and the cost in entropy (or money) in the measurement of very small quantities are derived and applied to a consideration of the accuracy and efficiency of measurements.

621.317:621.396.82 795

Radio Interference—(*Elect. Rev.*, (*London*), vol. 153, p. 563; Sept. 11, 1953.) A note of British Standards on interference measurements and of Electrical Research Association Reports Ref. M/T 116 and 117 describing appropriate measurement equipment.

621.317.089.6 796

Practical Calibration Adjustments for Apparatus which Obeys a Theoretical Law Imperfectly—J. W. Head. (*Electronic Eng.*, vol. 25, pp. 499–501; Dec., 1953.) Description of a method devised for calibrating a tone source for which the dial angle ϕ was theoretically related to the frequency f by the formula $\phi = A + B \log_{10} f$. The object was to obtain easily a calibration curve sufficiently smooth and accurate for practical purposes, rather than to find the unique curve satisfying some mathematical criterion of goodness of fit.

621.317.3:621.396.822 797

Valve and Receiver Noise Measurement at V.H.F.—N. Houlding. (*Wireless Eng.*, vol. 31, pp. 15–26; Jan., 1954.) Techniques for the measurement of noise factor, tube noise and other parameters involved in the investigation of receiver noise performance are described. Sources of error, and precautions required to minimize errors, are discussed. Equipment giving improved accuracy is described. Some measurements on noise generators and tube noise are reported.

621.317.32:621.385.832 798

Measurement of Voltage using a Simple Electron-Beam Valve—A. Lieb. (*Funk u. Ton*, vol. 7, pp. 463–471; Sept., 1953.) A detailed description is given of a tube of magic-eye type adapted to indicate the adjustment of a variable voltage to a desired setting. Two luminescent streaks, produced by independent beam-forming electrode systems, are brought into coincidence when the adjustment is correct.

621.317.33:621.372.413 799

Measurement of Resonant-Cavity Characteristics—G. L. Hall and P. Parzen. (PROC. I.R.E., vol. 41, pp. 1769–1773; Dec., 1953.) The system considered is a re-entrant cavity terminating a coaxial line. A method of determining the loaded and unloaded Q and the shunt resistance of the cavity is described, involving measurements of frequency shifts caused by introducing a small obstacle into the cavity. A high-stability high-resolution afc system for controlling the klystron oscillator is described.

621.317.333.6:621.372.8 800

A Standard Waveguide Spark Gap—D. Dettinger and R. D. Wengenroth. (*Trans. IRE*, vol. MTT-1, pp. 39–48; March, 1953.) Description and comparison of four types of spark gap used for testing the power-handling capacity of waveguides, namely (*a*) resonant-section, (*b*) swayback, (*c*) cylindrical-bump, (*d*) hemispherical-bump types.

621.317.335.3+621.317.411 801

Optical Methods for Measurement of Complex Dielectric and Magnetic Constants at Centimetre and Millimetre Wavelengths—T. E. Talpey. (*Onde élect.*, vol. 33, pp. 561–569; Oct., 1953.) Modifications necessary to take account of loss factors in basic formulas relating to transmission and reflection of a plane wave incident on a reflecting plate are discussed. Using formulas derived, permittivity k_e, permeability k_m and loss angles δ_e, δ_m can be determined, when losses are small, from (*a*) Brewster angle and transmission and reflection coefficients at this angle of incidence, when the plane of polarization is parallel to the plane of incidence, (*b*) the ratio of the moduli of the reflection coefficients with polarization parallel to and normal to the plane of incidence, (*c*) plate thickness and wavelength. Equipment for measuring these quantities comprises a klystron oscillator with associated wavemeter, attenuator and horn radiator, a receiver with horn, attenuator and detector, and a rotatable support for the sample. Experimental results for bakelite, glass, polystyrene and paraffin at λ 8.36 mm. are quoted.

621.317.34:621.372.8 802

Precision Measurement of Waveguide Attenuation—J. H. Vogelman. (*Electronics*, vol. 26, pp. 196–199; Dec., 1953.) A method of determining attenuation values between 0.01 and 0.5 db, and down to 0.001 db with lower accuracy is based on standing-wave measurements. The technique is useful for investigating the influence of the waveguide surface condition on the attenuation.

621.317.341.029.62/.65 803

Audio Modulation Substitution System for Microwave Attenuation Measurements—J. Korewick. (*Trans. IRE*, vol. MTT-1, pp. 14–21; March, 1953.) An arrangement for measuring attenuations up to 40 db over the frequency range 240 mc—40 kmc uses an audio-modulated klystron oscillator as a stable rf source and a barretter as a square-law detector. Attenuation produced in the microwave section by the system under test is compensated by adjustment of a standard attenuator in the audio section, the output level being held constant.

621.317.361.029.64 804

Techniques of Frequency Measurement in the Centimetre-Wave Region—E. G. Hope. (*Proc. IEE*, part IV, vol. 100, pp. 144–153; Oct., 1953. Digest, *ibid.*, part III, vol. 100, pp. 383–384; Nov., 1953.) Methods developed at the National Physical Laboratory and based on the 100-kc quartz-crystal standard are discussed. Frequencies up to 50 kmc can be measured with an error <1 part in 10^8. For producing the required standard frequencies in the centimetre-wave range, crystal diodes are used as harmonic generators. The properties of a number of types of crystal diode have been investigated and the optimum values of input power and bias voltage determined. Most types of Si diode and several types of Ge diode are suitable, the Ge types in general requiring less input power for the same harmonic output. On the basis of measurements, an approximate formula is derived for predicting the power in a given harmonic.

621.317.7:621.395.822 805

A Mains-Operated Psophometer—F. H. Goldsmith and J. A. Widdicks. (*P.O. Elect. Eng., Jour.*, vol. 46, part 3, pp. 112–114; Oct., 1953.) The psophometer is essentially a tube voltmeter measuring the rms voltage of a complex af signal and incorporating a frequency-weighting network. An experimental model is described in which the over-all error is <3 per cent.

621.317.723 806

Portable Quadrant Electrometer of High Sensitivity—G. F. Schilling and P. Kreager. (*Rev. Sci. Instr.*, vol. 24, pp. 877–878; Sept., 1953.) Description of an instrument developed in connection with the study of atmospheric electricity.

621.317.73:[546.28+546.289 807

Four-Probe Instrument for Resistivity Measurements of Germanium and Silicon—A. L. MacDonald, J. Soled, and C. A. Stearns. (*Rev. Sci. Instr.*, vol. 24, pp. 884–885; Sept., 1953.) A brief description of the construction of the instrument is given.

621.317.733:621.315.612.4 808

Some Dielectric Properties of Barium-Strontium Titanate Ceramics at 3000 Mc/s.—Davis and Rubin. (*See* 783.)

621.317.763.029.64/.65 809

A Microwave Fabry-Perot Interferometer—J. O. Artman. (*Rev. Sci. Instr.*, vol. 24, pp. 873–875; Sept., 1953.) Details are given of an interferometer for measurements in the wavelength range 5 mm—4 cm, using a movable totally reflecting surface parallel to a fixed partially reflecting surface composed of elements (e.g. metal balls) whose dimensions are much smaller than λ. A magic-T waveguide junction takes the place of the beam-splitting plate of the optical system.

621.317.78.029.6:536.62 810

Accurate R.F. Power Measurements—R. M. Soria and J. G. Krisilas. (*Radio & Telev. News, Radio-Electronic Eng. Section*, vol. 50, pp. 3–6, 29; Sept., 1953.) Continuous-flow colorimetric methods are used for rf power output measurements, in the range 2w–5 kw, and for the calibration of input-power indicators. The power-indicator component calibrated is isolated electrically from the thermocouple inserted in it by means of a quarter-wave transformer. Constructional details of the equipment used and performance curves are given.

621.397.621.2.001.4 811

Simple Linearity-Measuring Instrument—K. G. Beauchamp. (*Wireless World*, vol. 60, pp. 36–37; Jan., 1954.) A device on the lines of a traveling microscope is described for measuring the distance between pairs of parallel bars of a test pattern at different parts of the screen face.

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

531.77:621.383 812

A Photoelectric Decimal-Coded Shaft Digitizer—W. H. Libaw and L. J. Craig. (*Trans. IRE*, vol. EC-2, pp. 1–4; Sept., 1953.) A device is described for giving an indication of the position of a rotating shaft. Lamps illuminate photocells arranged round the shaft, in accordance with the position of slits in a screen attached to the shaft. Details are given of a decade system.

538.569.2.047 813

Capacity and Conductivity of Body Tissues at Ultrahigh Frequencies—H. P. Schwan and Kam Li. (PROC. I.R.E., vol. 41, pp. 1735–1740; Dec., 1953.) Results of measurements over the frequency range 200–1000 mc are analysed, and the variations are explained on a biological basis. Temperature variations are also investigated. Measuring technique is described.

621.316.729 814

Cathode-Ray Synchroscope and Automatic Synchronizer—M. A. -H. Ahmed. (*Elect. Eng.*, (*New York*), vol. 72, p. 808; Sept., 1953.) Summary only. Two voltages are compared for synchronism by applying them to a cr tube so that one produces a circular trace while the other produces radial pips. Automatic synchronization is obtained by using a cr tube with a two-electrode target in conjunction with a relay system.

621.317.083.7:621.396.91 815

Automatic Radio Equipment for Long-Period Operation for Long-Range Transmissions of Weather Data—E. Plötze, K. Rawer, and E. Stoebe. (*Z. angew. Phys.*, vol. 5, pp. 351–359; Sept., 1953.) Equipment for short-wave meteorological stations for use on sea or land is described. Operational experience, with equipment used in the Arctic and the Atlantic regions is discussed.

621.319.339 816

The Design of the Electric Field in a Van de Graaff Generator—J. W. Boag. (*Proc. IEE*, part IV, vol. 100, pp. 63–82; Oct., 1953.)

621.319.339:[621.398+621.317.083.7 817

A Remote Control and Telemetering Sys-

tem for a Van De Graaff Generator—B. Millar. (*Electronic Eng.*, vol. 25, pp. 446–450 and 506–508; Nov./Dec., 1953.) A system using modulated light beams is described.

621.384.611 818
Vertical Focusing in the Microtron—J. S. Bell. (*Broc. Bhys. Soc.*, vol. 66, pp. 802–804; Sept. 1, 1953.) A theoretical study is made of the vertical focusing oscillations. See also 2090 of 1953 (Henderson et al.).

621.384.612 819
Stability of Orbits in a Strong-Focusing Synchrotron—S. Lundquist. (*Bhys. Rev.*, vol. 91, pp. 981–983; Aug. 13, 1953.)

621.384.612 820
Proton Synchrotron of the University of Birmingham—(*Nature*, (*London*), vol. 172, pp. 704–706; Oct. 17, 1953.) Preliminary tests of the machine are reported. See also 700 of 1951 (Hibbard).

621.384.612 821
The Cosmotron—a Review—M. H. Blewett (Ed.). (*Rev. Sci. Instr.*, vol. 24, pp. 725–870; Sept., 1953.) A series of papers covering all aspects of the Brookhaven proton synchrotron.

621.385.83:[621.317.329+517.944 822
Electrostatic Potential Plotting for Use in Electron-Optical Systems—Kuo-Chu Ho and Moon. (*See* 912.)

621.385.833 823
A Method for the Direct Measurement of the Caustic Surfaces of Electron Lenses—W. Scheffels, M. Hahn, and F. Lenz. (*Optik, Stuttgart*, vol. 10, pp. 455–458; 1953.)

621.385.833 824
Correction of Electrostatic Lenses by Departure from Rotational Symmetry—J. C. Burfoot. (*Proc. Phys. Soc.*, vol. 66, pp. 775–792; Sept. 1, 1953.)

621.385.833 825
Determination of Focal Lengths of Unipotential Lenses by the Rotating-Beam Method—R. V. Jordan, D. W. Shipley, and M. Krawitz. (*Sylvania Technologist*, vol. 6, pp. 92–95; Oct., 1953.) Measurements were made on a three-cylinder unipotential lens modified by inserting apertured diaphragms, by varying the length of the focusing (middle) cylinder, and by varying the spacing between the cylinders. The results are shown graphically.

621.387.424:550.8 826
Electronic Equipment used for Geological Research at Depth by Radioactivity Methods—J. Berbezier. (*Onde élect.*, vol. 33, pp. 553–560; Oct., 1953.) The equipment comprises a G-M-counter probe lowered down the bore-hole on a cable, an automatic depth recorder, pulse integrator and recorder. Records reproduced show the natural and the neutron-induced gamma radiation from different strata at depths down to 680 m.

621.387.424:550.8 827
Radioactivity Method of Prospecting for Uranium Ores—C. Lallemant. (*Onde élect.*, vol. 33, pp. 547–552; Oct., 1953.) Review of the technique, including descriptions and circuit details of French equipment for the detection and measurement of radioactivity.

PROPAGATION OF WAVES

538.566:535.42 828
Diffraction of Electromagnetic Waves near the Earth's Surface in an Optically Inhomogeneous Medium—R. Schachenmeier. (*Arch. elekt. Übertragung*, vol. 7, p. 491; Oct., 1953.) Correction to paper abstracted in 238 of 1952.

621.396.11:550.38:551.510.535 829
Measurements of the Terrestrial Magnetic Field in the E-Layer—Cutolo. (*See* 720.)

621.396.11:551.510.535 830
Prediction of Ionospheric Propagation for Distances greater than 10000 km—E. Harnischmacher. (*Compt. Rend. Acad. Sci.*, (*Paris*), vol. 237, pp. 1071–1073; Nov. 2, 1953.) The method discussed is developed from that previously described by Rawer (199 of 1953) and is based on the assumption that in very-long-distance propagation reflections occur at both *F* and *E* layers; the total number of hops is greater than for pure *F*-layer propagation and the absorption is therefore higher, but the blanketing effect of the *E* and E_s layers is eliminated. The values of the different possible angles of departure are close together for very-long-distance circuits, and the wave in effect adapts its path to the ionospheric conditions along the route. Experimental results obtained on a 17,000-km path confirm predictions made on this basis.

621.396.11:551.510.535 831
Results relating to the Critical Frequency and the Transmission Factor of the Ionosphere F_1 Layer—E. Theissen. (*Compt. Rend. Acad. Sci.*, (*Paris*), vol. 237, pp. 1104–1106; Nov. 2, 1953.) Using values measured at Freiburg in the formula $f_0F_1=k\cos^n z$ (z is the zenithal angle of the sun, k is the critical frequency for $z=0$) the mean value of n for the months March-September was found to be 0.22. No seasonal or eleven-yearly variation of its value was found. The value of k depends on the sunspot number. The F_1 transmission factor (M3000) has a diurnal and seasonal variation represented by $M_0\cos^m z$, the value of m being 0.08 ± 0.02. The observations also indicate that the F_1 layer rises as solar activity increases.

621.396.11:551.594.5 832
A Note on Auroral Interaction—N. C. Gerson. (*Jour. Atmos. Terr. Phys.*, vol. 4, pp. 81–82; Sept., 1953.) The modulation of a radio wave due to a moving auroral reflecting screen is discussed.

621.396.81.029.62:551.593 833
The Increase of U.S.W. Field Strength by a Refracting Tropospheric Layer (Inversion)—R. Schachenmeier. (*Arch. elekt. Übertragung*, vol. 7, pp. 485–491; Oct., 1953.) Expressions are derived for the effect of an inversion layer on the field strength at points beyond the horizon. A practical example is worked out. When the receiving antenna is far beyond the horizon and the inversion layer lies below the transmitting antenna, the field strength is increased.

621.396.812.029.62/.63 834
Investigation of the Influence of the Troposphere on the Propagation of Ultra-Short Waves—R. Schachenmeier. (*Arch. elekt. Übertragung*, vol. 7, p. 491; Oct., 1953.) Correction to paper abstracted in 2524 of 1951.

RECEPTION

621.376.233:621.314.632 835
Crystal-Mixer Design at Frequencies from 20,000 to 60,000 Mc/s—Ditchfield. (*See* 890.)

621.396.621:621.314.7 836
Experimental Transistor Receiver—B. R. Bettridge. (*Wireless World*, vol. 60, pp. 2–5; Jan., 1954.) Two two-transistor circuits for local-station reception are described. The total consumption is 6 ma at 18 v; acceptable volume is obtained with an input of about 20 mw to a sensitive loudspeaker. Reflaxing is used to improve sensitivity in the more elaborate circuit.

621.396.621:621.396.822 837
First Probability Densities for Receivers with Square-Law Detectors—R. C. Emerson. (*Jour. Appl. Bhys.*, vol. 24, pp. 1168–1176; Sept., 1953.) A procedure is indicated for using the Kac-Siegert method (3645 of 1947) in its widest generality without the necessity of finding eigenvalues and without dealing with the characteristic function at all; it involves expanding the density function in an orthonormal series, the coefficients of which are expressed in terms of cumulants, which in turn are obtained from the system kernel. A receiver with Gaussian IF and Gaussian af pass characteristics is treated in detail.

621.396.621.57:621.376.3:621.314.7 838
A Portable Transistor F.M.-Receiver—R. C. Ballard. (*Tele-Tech.* vol. 12, pp. 79, 206–207; Aug., 1953.) Eleven point-contact Ge transistors and four Ge diodes are used in an experimental receiver giving an over-all amplification of 67 db and an undistorted output of 75 mw. The collector-current drain is 60 ma. Circuit details are given.

621.396.812.3 839
Evaluation of Polarization Diversity Performance—J. L. Glaser and L. P. Faber, Jr. (PROC. I.R.E., vol. 41, pp. 1774–1778; Dec., 1953.) Experiments on the reduction of fading effects are reported. Measurements were made on unmodulated signals of frequencies 6.985 and 11.66 mc transmitted from Red Bank, N. J., and received near St. Louis, Mo. separate antennas being used to receive the vertically and horizontally polarized components. The results on 11.66 mc were nearly equal to those which would be produced by independent Rayleigh distributions of signal amplitude for the two components. On 6.985 mc the improvement due to the diversity reception was not so great.

621.396.82:621.317. 840
Radio Interference—(*See* 795.)

621.396.828:621.327.43 841
Present Position as regards Suppression of Radio Interference from Fluorescent Lamps—W. Rüegg. (*Bull. schweiz. elektrotech. Ver.*, vol. 44, pp. 804–805; Sept. 5, 1953. Discussion, pp. 805–807.)

551.594.6:621.396.822 842
Radio Research Special Report No. 26. Measurements of Atmospheric Noise at High Frequencies during the years 1945–51. [Book Notice]—F. Horner. Publishers: H. M. Stationery Office, London, 1953, 1s. 9d. (*Govt. Publ.*, (*London*), p. 21; Sept.)

STATIONS AND COMMUNICATION SYSTEMS

621.39:621.376 843
Applications of Polyphase Modulation in Telecommunications—S. Silleni. (*Poste e Telecomunicazioni*, vol. 21, pp. 403–415; Sept., 1953.) Some particularly difficult filtering problems can be solved by use of polyphase modulation. The basis of the method is explained and applications are described, including a frequency-shift radiotelegraphy system and transmitters and receivers for ssb radiotelephony. Phase changers, modulators and mixers are described. The usefulness of the system for economizing on bandwidth is indicated. 45 references.

621.39.001.11 844
Introduction to Communication Theory—E. H. Harwood. (*Trans. S. Afr. Inst. Elect. Eng.*, vol. 44, part 8, pp. 241–250; Aug., 1953.)

621.39.001.11 845
Bits, Language Efficiency and Information Theory—R. L. Shuey. (*Gen. Elect. Rev.*, vol. 56, pp. 15–19; Sept., 1953.) The basic concepts of communication theory are simply explained.

621.39.001.11:519.272 846
Correlation and Autocorrelation in Communication Engineering—W. Meyer-Eppler. (*Arch. elekt. Übertragung*, vol. 7, pp. 501–504 and 531–536; Oct./Nov., 1953.) The common correlation functions and coefficients are defined and their meanings are explained in physi-

cal terms. Numerous applications are noted to problems in physics (e.g. interference) and, in particular, to problems in communication and acoustic engineering, e.g. recognition of signals in noise, objective determination of the acoustic quality of a room, etc. Correlatographs are also discussed. Special devices such as a reading apparatus for the blind and a device for the automatic recognition of the spoken word are mentioned. 46 references.

621.395.43/.44 847
Inter Channel Interference in Multichannel Carrier Telephone Systems—S. Dossing. (*Telecommun. Jour. Aust.*, vol. 9, pp. 101–108; Oct., 1952.) Various forms of interchannel interference are described, and methods of measurement are discussed.

621.395.63:621.396.5 848
Selective Calling for Radio-Telephone Systems—J. R. Pollard. (*Electronic Eng.*, vol. 25, pp. 490–496; Dec., 1953.) R/T systems consisting of a master station and a number of subsidiary stations are considered, and three alternative circuit arrangements are described for use at subsidiary stations to enable individual, group or general calls to be made. Each arrangement includes a pulse-counting section and a discriminator section; dekatrons and/or cold-cathode trigger triodes are used.

621.396.41:621.376.3 849
Some Recent Developments in the Multiplexed Transmission of Frequency Modulated Broadcast Signals—E. H. Armstrong and H. J. Bose. (*Proc. Radio Club Amer.*, vol. 30, pp. 3–13; 1953.) An account of the two-channel system operated at Alpine, New Jersey (KE2XCC). The main carrier is frequency-modulated by a subcarrier of frequency 27.5 kc; both main carrier and subcarrier are individually frequency-modulated with program material, the maximum deviation of the former being about 50 kc and of the latter 5 kc. The maximum modulation frequency is 15 kc for the main channel and 7.5 kc for the second channel. Cross modulation at the transmitter is avoided by keeping the channels separate up to a stage where the normal circuit requirements call for a bandwidth sufficient to ensure good phase linearity. At the receiver, the first discriminator must be carefully designed to avoid introduction of cross modulation. Performance tests are reported; signals received at a level of $<10\mu$v are intelligible.

621.396.65:621.396.41.029.63 850
Portable Microwave for Allied Forces in Europe—M. G. Staton. (*Electronics*, vol. 26, pp. 130–134; Dec., 1953.) The radio relay system described comprises 7 terminal stations and 18 repeater stations, and provides 24 voice channels. The equipment is truck mounted and includes a 58-foot telescoping aerial tower. A fm system is used which makes interception difficult.

621.396.65.029.62 851
Design Considerations for V.H.F. Link Radio Equipment—B. Wilson. (*G.E.C. Telecommun.*, pp. 16–26; Sept., 1953.) General design of 54–330-mc point-to-point R/T equipment is discussed. Both am and fm equipments are considered.

621.396.712:621.396.61 852
The R.T.F. Transmitting Stations at Sélestat and Allouis L.W.—Gaillard. (*See* 886.)

621.396.712.029.62 853
Radio and Television in [Western] Germany—(*Electronic Eng.*, vol. 25, pp. 497–499; Dec., 1953.) Operating frequency and power of the 90 or so vhf stations are tabulated.

621.396.712.3 854
The Technical Equipment of the B.B.C. Swansea Studios—W. J. Stentiford. (*B.B.C. Quart.*, vol. 7, pp. 169–173; Autumn, 1952. Proc. I.R.E. (*Australia*), vol. 14, pp. 270–273; Nov., 1953.)

621.396.7 855
Construction of a Mountain-Top Remote Base Station—H. V. Church. (*Commun. Eng.*, vol. 13, pp. 22–25, 38; Sept./Oct., 1953.) An account of the 250-w station of the Central Vermont Public Service Corporation, installed on Pico Peak, altitude 4000 feet. The station is remotely controlled by land-line from headquarters 12 miles away. Installation and maintenance problems peculiar to such a location are discussed in detail.

621.396.721 856
Two-Band Transmitter-Receiver—G. P. Anderson. (*Wireless World*, vol. 60, p. 37; Jan., 1954.) Correction to paper noted in 530 of February.

621.396.97:621.396.66 857
The Automatic Monitoring of Broadcast Programmes—H. B. Rantzen, F. A. Peachey, and C. Gunn-Russell. (*Proc. IEE*, part III, vol. 100, pp. 372–373; Nov., 1953.) Discussion on 269 of 1952.

SUBSIDIARY APPARATUS

621-526 858
A Nonlinear Servomechanism with Several Independent Variables—D. Mitrovic. (*Compt. Rend. Acad. Sci.* (*Paris*), vol. 237, pp. 1209–1211; Nov. 16, 1953.)

621.311.6:539.16 859
Radioactive Charging Effects with a Dielectric Medium—P. Rappaport and E. G. Linder. (*Jour. Appl. Phys.*, vol. 24, pp. 1110–1114; Sept., 1953.) The characteristics of a cell consisting of a Sr^{90}-$Y^{90}\beta$-ray source, a polystyrene dielectric separator and a collector made of carbon or metal, were investigated. Radioactive current and voltage sources similar to this cell are feasible. The arrangement offers a simple way of studying the effects of radiation on electrical processes in solids.

621.314.634 860
The Problem of Heating in the Selenium Rectifier—W. Stiassny. (*Elektrotech. U. Maschinenb.*, pp. 409–413, 437–441, and 455–460; Sept. 15th–Oct. 15th, 1953.) Formulas for the calculation of heat losses are derived. Design for good efficiency and low temperature rise is discussed in detail, with reference to the operational demands of various applications in power rectification. Typical characteristics curves are given.

621.314.65 861
Recent Developments in Ignitrons—G. M. Zins. (*Electronics*, vol. 26, pp. 135–137; Dec., 1953.)

621.316.722 862
Stabilization Problems in Physics—P. Goudal. (*Cah. Phys.*, no. 45, pp. 40–55; Sept., 1953.) A review of voltage, current, and magnetic-field regulators. The performances of various stabilizing valve circuits and primary regulators are compared, and the importance of good control of filament heating voltages is emphasized. Special problems of stabilization in nuclear physics are mentioned.

621.316.722:621.311.6 863
A Stabilized D.C. Supply Unit for Output Voltages of 0 to 300 V—D. J. H. Admiraal. (*Elec. Appl. Bull.*, vol. 14, pp. 61–71; May, 1953.) A circuit is described in which the whole of the output-voltage variation is available for controlling the amplifying tube, so that the gain is the same for any output voltage down to zero. The control tube is a pentode whose screen-grid voltage is stabilized by means of a stabilizer tube; the filaments of the amplifying tubes, which are fed from this source, have low consumption. Variation of the output voltage is +2 mv for mains fluctuations up to 10 per cent.

621.316.722:621.387 864
Relaxation Oscillations in Voltage-Regulator Tubes—P. L. Edwards. (Proc. I.R.E., vol. 41, pp. 1756–1760; Dec., 1953.) Relaxation oscillations may occur if the regulator tube is shunted by a capacitor and the load line intersects the tube characteristic on the low-current side of the minimum. Methods of modifying the circuit to prevent these oscillations are indicated.

621.316.722.1:621.311.6 865
An Alternating-Current Stabilizer—P. A. V. Thomas. (*Electronic Eng.*, vol. 25, pp. 522–523; Dec., 1953.) A stabilizer for a tube-heater power supply uses a diode operating with low heater voltage as the error detector and a transductor as the control element. The output voltage can be maintained constant to within ±1 per cent.

621.373.4 866
Industrial Tube Generator for Low Frequencies—H. Hertwig and F. N. Wissing. (*Elec. Appl. Bull.*, vol. 14, pp. 72–75; May, 1953.) A detailed description is given of a three-phase tube generator suitable for supplying an asynchronous motor at frequencies from 1 to 2 kc.

TELEVISION AND PHOTOTELEGRAPHY

621.397.2(41) 867
Television Service to Belfast—T. Kilvington. (*P.O. Elect. Eng. Jour.*, vol. 46, part 3, pp. 130–133; Oct., 1953.) "Vision signals for the B.B.C. temporary television transmitter at Belfast are picked up direct from Kirk o' Shotts on 56.75 mc at a receiving site on Black Mountain and passed on a carrier of 6.12 mc over about a mile of coaxial cable to the temporary transmitter site in Glencairn, whence they are re-broadcast on a carrier of 45 mc."

621.397.26:621.385.029.63:621.376.3 868
A 50-Watt F.M. Magnetron for Relay Service—Kennedy. (*See* 904.)

621.397.5:535.623 869
The American Television Scene—M. J. L. Pulling. (*Wireless World*, vol. 60, pp. 13–15; Jan., 1954.) Impressions reported by a visiting British engineer, particularly of the color-television demonstration staged on October 15, 1953.

621.397.5:535.623 870
Compatible Colour Television—D. A. Bell. (*Wireless World*, vol. 60, p. 31; Jan., 1954.) Sideband interference problems involved in using the NTSC color-subcarrier system with the British television system are discussed; the narrower video-frequency band is the most serious difficulty.

621.397.5:535.623 871
The N.T.S.C. Color-Television Standards—D. G. Fink. (*Electronics*, vol. 26, pp. 138–150; Dec., 1953.) The final NTSC compatible-color signal specifications, presented in July, 1953, are discussed in detail.

621.397.5:621.39.001.11 872
The Impact of Information Theory on Television—D. A. Bell. (*Jour. Brit. I.R.E.*, vol. 13, pp. 590–591; Dec., 1953.) Discussion on 3731 of 1953.

621.397.5(41) 873
An Outline of the British Television System: Part 2—Transmitting the Picture Waveform—D. Wray. (*P.O. Elect. Eng. Jour.*, vol. 46, part 3, pp. 123–128; Oct., 1953.) The five-channel vestigial-sideland broadcasting system is outlined; operating frequency and power are tabulated for the ten stations. The transmitters are connected to the London studios by cable and radio links. Outside-broadcast material is transmitted over short distances either by coaxial or balanced-pair

cable, portable radio links, or ordinary telephone pairs. Part 1: 271 of February.

621.397.611:621.375.232 874

Modified Preamplifier improves Movie Telecasts—K. B. Benson. (*Electronics*, vol. 26, pp. 166–169; Dec., 1953.) A preamplifier circuit for use with an ionoscope combines a cascode arrangement with negative feedback. Advantages claimed are reduction of noise, of beam-current requirements and of spurious signals, and improvement in the rendering of the grey scale.

621.397.611.2:621.385.832 875

A Television Camera with an Image Iconoscope—C. J. Seur. (*Commun. News*, vol. 14, pp. 29–34; Sept., 1953.) The equipment used in the Bussum studio for experimental transmissions is described.

621.397.621.2.001.4 876

Simple Linearity-Measuring Instrument—Beauchamp. (*See* 811.)

621.397.7 877

Studio Equipment used for Television Broadcasting in the Netherlands—J. M. Olthuis. (*Commun. News*, vol. 14, pp. 19–28; Sept., 1953.) Description of the equipment of the studios at Bussum, near Amsterdam.

621.397.7:534.86 878

The Sound Equipment in the Television Studio at Bussum—A. Cramwinckel. (*Commun. News*, vol. 14, pp. 34–39; Sept., 1953.)

621.397.82 879

A Level Compensator for Telephotograph Systems—T. A. Jones and W. A. Phelps. (*Elect. Eng.*, vol. 72, pp. 787–791; Sept., 1953.) The interference modulation in picture transmission via wide-band carrier equipment is effectively cancelled out by introducing an equal and opposite interference signal obtained by detecting a single-frequency pilot current transmitted simultaneously with the picture. Block diagrams and performance characteristics are given.

621.397.621.2:621.316.729 880

Flywheel Synchronization of Sawtooth Generators [Book Review]—P. A. Neeteson. Publishers: Cleaver-Hume Press, London, 156 pp., 21s. (*Wireless Engr.*, vol. 31, pp. 27–28; Jan., 1954.) " . . . a necessary book for the designer."

TRANSMISSION

621.376.223 881

Balanced Crystal-Diode Modulator—W. F. Byers. (*Radio & Telev. News, Radio-Electronic Eng. Section*, vol. 50, pp. 10–11, 27; Sept., 1953.) Description of the low-power Si-diode modulator Type 1000-P7, giving linear operation over the range 0–20 mc at carrier frequencies from 60 mc to 2.5 kmc. Circuit diagram and performance figures are given.

621.396.61.029.58:621.396.65 882

Single-Sideband Multi-Channel Operation of Short-Wave Point-to-Point Radio Links: Part 4(a)—An Independent-Sideband High-Power Short-Wave Transmitter—The Radio and Power Units—H. E. Sturgess and F. W. Newson. (*P.O. Elect. Eng. Jour.*, vol. 46, part 3, pp. 140–143; Oct., 1953.) The transmitter can provide peak power up to 70 kw in the frequency range 4–22 mc. By using the two-channel drive unit described in part 2 [2175 of 1953 (Owen & Ewen)] the transmitter can also be used for dsb telephony and cw and mcw telegraphy.

621.396.61.029.62 883

A New V.H.F. Transmitter for Frequency Modulation—W. Grimbaldeston. (*G.E.C. Telecommun.*, pp. 27–33; Sept., 1953.) Description of the BRT-108 250-W transmitter, for 71.5–100 mc. Ph. m. corrected to fm over the required audio range is used. The nominal frequency deviation is ±15 kc for 0.5 mv across the 15-Ω input, at 1 kc modulation frequency.

621.396.662:621.316.7 884

Automatic Control System with Provision for Scanning and Memory—N. H. Young. (*Elect. Eng., N. Y.*, vol. 72, pp. 782–784; Sept., 1953.) The control element (e.g. a tuning capacitor) is scanned through its entire range of adjustment and the input voltage is fed, via a diode, to the "memory" capacitor, causing it to charge up to the maximum peak value. On re-scanning, the input voltage is compared with this peak value; the control element is stopped when they are equal. A simplified circuit diagram is given, and a radio transmitter embodying the system is briefly described.

621.396.665 885

Circuits for Limiting Peak Voltages—E. G. Beard. (*Philips Tech. Commun. (Aust.)*, no. 3, pp. 11–15; 1953.) A system of amplified agc for preventing overmodulation of a transmitter is described. The peak signal voltages trigger a quiescent 1-mc oscillator which then oscillates in a series of pulses. The length of the pulse sequence is a function of the signal amplitude. The rectified and integrated pulses are used for the agc bias.

621.396.712:621.396.61 886

The R.T.F. Transmitting Stations at Sélestat and Allouis L.W.—A. Gaillard. (*Onde élect.*, vol. 33, pp. 489–496; Aug./Sept., 1953.) The long-wave transmitter at Allouis, which was destroyed in 1944, was re-started in October, 1952. The power is 250 kw; it is planned to add a second transmitter to bring the total power up to 450 kw. Anode modulation is used, with two Type-E3056 tubes in push-pull in the rf stage. The antenna is a folded unipole designed to handle a bandwidth 12.4 per cent of the carrier frequency; its total height is 308 m. The new Sélestat station, intended to serve the whole of Alsace, also came into full operation in October, 1952. It has two 150-kw transmitters, each comprising two units. There are two widely spaced antennas, one 115 m and the other 90 m high. The heat developed at the anodes of the power valves is recovered and used for heating the buildings. See also 1735 of 1952.

TUBES AND THERMIONICS

621.314.632 887

Post-Injection Barrier Electromotive Force of *p-n* Junctions—B. R. Gossick. (*Phys. Rev.*, vol. 91, pp. 1012–1013; Aug. 15, 1953.) By injecting carriers across a *p-n* junction with a high-back-voltage point-contact diode in series, the post-injection barrier emf may be observed under approximately open-circuit conditions. From measurements using a CK708 diode, the calculated emf is ~0.2 v at room temperature.

621.314.632:546.289 888

Effect of Transit Time on Ge-Rectifier Behavior—R. Bray and B. R. Gossick. (*Phys. Rev.*, vol. 91, pp. 1011–1012; Aug. 15, 1953.) The forward characteristics of Ge point-contact rectifiers were measured using 0.4-μs pulses. Resistance was very much higher at the beginning of the pulse than at the end, when it reached the dc value. Thus transit times <0.4 μs are involved. In *p-n*-junction rectifiers the resistance takes longer to change, and is still much higher than the dc value at the end of a 3.6-μs pulse.

621.314.632:546.289 889

The Manufacturing and Testing of Germanium Rectifiers—C. Peters and H. Strong. (*G.E.C. Telecommun.*, pp. 34–39; Sept., 1953.) An illustrated account dealing with point-contact Ge diodes.

621.314.632:621.376.233 890

Crystal-Mixer Design at Frequencies from 20,000 to 60,000 Mc/s—C. R. Ditchfield. (*Proc. IEE*, part III, vol. 100, pp. 365–371; Nov., 1953.) Crystal valves designed during the war are reviewed. A new design of plug-in waveguide type is described and some performance figures are given. With a minor modification to the holder, this type can be used as a harmonic generator.

621.314.7 891

A Germanium *N-P-N* Alloy Junction Transistor—D. A. Jenny. (Proc. I.R.E., vol. 41, pp. 1728–1734; Dec., 1953.) The transistor discussed is the counterpart of the *p-n-p* type described by Law *et al.* (876 of 1953). It is made by fusing Pb-Sb alloy into both faces of a thin wafer of *p*-type single-crystal Ge. Compared with the *p-n-p* type, the penetration of the alloy is more uniform, giving flatter junctions and better control of junction spacing. Test figures for a typical lot of 100 units are given; the best values obtained are 45 db for the power gain, 0.997 for α and 3 db for the 1-kc noise factor. The hf performance is better than that of the *p-n-p* type, but the improvement is not so great as would be expected from the electron/hole mobility ratio.

621.314.7 892

Home-Made Transistors—P. B. Helsdon. (*Wireless World*, vol. 60, pp. 20–23; Jan., 1954.) Practical details are given for converting selected Ge diodes into point-contact transistors.

621.314.7 893

The Surface-Barrier Transistor: Part 1—Principles of the Surface-Barrier Transistor—W. E. Bradley. (Proc. I.R.E., vol. 41, pp. 1702–1706; Dec., 1953.) The "surface-barrier" transistor comprises a plate of *n*-type single-crystal Ge with the thickness at a central region reduced to a few microns, and emitter and collector electrodes plated respectively on to the two faces at the thinned region. A method of production is used which permits accurate control of the geometry. An explanation is given of the hole-emission, conduction and collection mechanisms involved in the operation; this depends on the formation of a layer about 0.0001 in. thick just below the Ge surface, within which there are practically no free charge carriers. Efficient operation at frequencies >60 mc has been achieved with a supply voltage of 3 v.

621.314.7 894

The Surface-Barrier Transistor: Part 4—On the High-Frequency Performance of Transistors—R. Kansas. (Proc. I.R.E., vol. 41, pp. 1712–1714; Dec., 1953.) A theoretical determination of the α-cut-off frequency for the surface-barrier transistor is given, based on analysis presented by Steele (881 of 1953) for junction transistors. Values found from the theory are compared with experimental values. The effect of nonuniformity of the thickness of the Ge is demonstrated. Part 3: 896 below.

621.314.7:537.311.33 895

The Surface-Barrier Transistor: Part 5—The Properties of Metal-to-Semiconductor Contacts—R. F. Schwarz and J. F. Walsh. (Proc. I.R.E., vol. 41, pp. 1715–1720; Dec., 1953.) An investigation is made of the properties of the plated In-Ge junctions formed by the technique used in the production of the surface-barrier transistor (*see* 896 below). Measured *I/V* characteristics are only slightly different from those for alloyed junctions. The shape and capacitance of the barrier are discussed; from a comparison of measured capacitance values with theoretically derived values it is inferred that the effective area of the barrier is of the same order of magnitude as the actual area of the plated electrode. Expressions are derived for the hole and electron currents across the barrier, and it is shown that enhanced hole current is obtained in the transistor as a result of the relatively small distance between the emitter and collector electrodes. Part 4: 894 above.

621.314.7.002.2 896

The Surface-Barrier Transistor: Part 2—Electrochemical Techniques for Fabrication of Surface-Barrier Transistors—J. W. Tiley and R. A. Williams. (PROC. I.R.E., vol. 41, pp. 1706–1708; Dec., 1953.) Details are given of the method used to reduce the thickness of the Ge plate (*see* 893 above). Two glass nozzles of diameter about 0.005 inch are mounted so as to direct jets of electrolyte on to the two faces of the plate, the latter being connected as anode. An even etch is obtained. The influence of illumination and of the high resistivity of the surface barriers on the passage of the etching current is discussed. When the etching is completed, the polarity of the system is reversed and the transistor electrodes are plated on using the same arrangement of equipment. Experiments indicate that In is a suitable metal for the electrodes. In typical units the diameter of the etched pit is 0.015 inch, that of the emitter is 0.003 inch and that of the collector 0.006 inch. The unit is provided with a Ni base tab by which it is mounted on a glass stem. Part 1: 893 above.

621.38.002.2:53 897

Physics in the Electronic Valve Industry—J. Thomson (*Brit. Jour. Appl. Phys.*, vol. 4, pp. 262–267; Sept., 1953.) The importance of physics in the development and manufacturing stages of production of various electronic devices is indicated.

621.385:621.372.57 898

Starvation Circuits and their Limitations—Erdle. (*See* 680.)

621.385:621.396.662 899

Tuning-Indicator Valves—F. Malsch. (*Elektrotech. Z., Edn A*, vol. 74, pp. 497–500; Sept. 1, 1953.) Description of the construction and operation of various types of indicator tube, including some relatively little used ones.

621.385:681.142 900

The Univac Tube Program—Hinkelman and Kraus. (*See* 647.)

621.385.029.6 901

Some Recent Work in France on New Types of Valves for the Highest Radio Frequencies—R. Warnecke and P. Guénard. (*Proc. IEE*, part III, vol. 100, pp. 351–362; Nov., 1953.) The tubes reviewed include reflex klystrons, multicavity klystrons, velocity-modulation tubes with distributed buncher, traveling-wave valves, magnetrons, magnetron-type traveling-wave valves, and backward-wave tubes (called carcinotrons). Theory is given, design aspects are discussed, and some performance figures are presented. References. to papers dealing with these tubes in greater detail are included.

621.385.029.6:621.372.2 902

Analysis of a Transmission-Line Type of Thermionic-Amplifier Valve—I. A. D. Lewis. (*Proc. IEE*, part IV, vol. 100, pp. 16–24; Oct., 1953.) Analysis is presented for a line comprising two helices in proximity to an earthed straight conductor. Two waves in each direction, with different phase velocities, can coexist. The design of a tube is discussed with a cylindrical cathode and coaxial helical grid and anode. Waves in the slower mode, in which anode and grid voltages are out of phase, are amplified according to an exponential law; waves in the faster mode, in which anode and grid voltages are in phase, are attenuated by a similar amount. For perfect matching at the ends of the line, the two helices must be wound in opposite senses and the coefficients of inductive and capacitive coupling must be equal. With a tube of this type a balanced output could be obtained with an unbalanced input.

621.385.029.63/.64 903

Electron Flow through Small Tubes with Magnetic Focusing—J. L. Stewart. (*Jour. Appl. Phys.*, vol. 24, pp. 1236—1240; Sept., 1953.) A calculation is made of the beam current flowing through a narrow tube or between a pair of parallel plates, taking account of the helical electron motion due to the magnetic focusing. The results are presented graphically. Expressions are also given for the current intercepted and for an equivalent beam conductance relating the power associated with the rotational motion of the beam to the intensity of an applied transverse electric field. The theory is applicable to traveling-wave tubes.

621.385.029.63:621.376.3:621.397.26 904

A 50-Watt F.M. Magnetron for Relay Service—D. P. Kennedy. (*Tele-Tech.*, vol. 12, pp. 66–68; Aug., 1953.) Outline descriptions are given of the QK-174C magnetron oscillator, which is continuously tunable over the frequency range 1.99–2.11 kmc, and of a television relay transmitter incorporating it. Associated wide-band fm receiver is also described.

621.385.029.64 905

Low-Noise Traveling-Wave Tubes for X-Band—D. A. Watkins. (PROC. I.R.E., vol. 41, pp. 1741–1746; Dec., 1953.) Tests on tubes using velocity jumps for noise reduction (1470 of 1952) show that best results are obtained with a single-jump arrangement in which the electrodes are shaped so as to make the transition from the low-voltage to the high-voltage space relatively gradual. A tube with a noise figure of 11.3 db and a gain of 18 db at 9 kmc is described. The variation of noise figure with magnetic field, operating voltage and cathode temperature is shown graphically.

621.385.032.216 906

The Life of Oxide Cathodes in Modern Receiving Valves—G. H. Metson, S. Wagener, M. F. Holmes, and M. R. Child. (*Proc. IEE*, part III, vol. 100, pp. 371–372.) Discussion on 1781 of 1952.

621.385.032.216:621.317.332 907

The Dependence of Mutual Conductance on Frequency of Aged Oxide-Cathode Valves and its Influence on their Transient Response—J. R. Tillman, J. Butterworth, and R. E. Warren. (*Proc. IEE*, part IV, vol. 100, pp. 8–15; Oct., 1953.) Full paper. See 2838 of 1953.

621.385.1 908

Valves Codes—M. H. N. Potok. (*Wireless World*, vol. 60, pp. 38–40; Jan., 1954.) An examination of the possibility of devising a method of designation which will serve not only to distinguish valves which are not interchangeable but also to give information about the properties of the tube designated.

621.385.2 909

The Space-Charge Smoothing Factor: Part 3—C. S. Bull. (*Proc. IEE*, part IV, vol. 100, pp. 47–50; Oct., 1953.) In a previous paper (2383 of 1950), thirty partial differential coefficients were enumerated which together express the characteristics of a diode. A study of the effect of fluctuations on one of these coefficients brings to light a serious error in all prior work on the subject. As a result, it may be assumed that the total emission fluctuates according to the law derived by Schottky in 1918, and estimates of the fluctuations can hence be obtained in closer agreement with values observed experimentally. Part 2: 291 of 1953.

621.385.2.029.63 910

A Disc-Seal Triode as a U.H.F. Amplifier—S. C. Peek. (*Sylvania Technologist*, vol. 6, pp. 81–85; Oct., 1953.) The construction of the Type-6BA4 planar triode is described, and the results of performance tests in a 450–900-mc grounded-grid coaxial amplifier are given. At 890 mc a power gain of 14 db and a noise figure of 10 db were obtained.

621.385.83 911

Spatially Alternating Magnetic Fields for Focusing Low-Voltage Electron Beams—J. R. Pierce. (*Jour. Appl. Phys.*, vol. 24, p. 1247; Sept., 1953.) A note referring to the work of Courant *et al.* (1454 of 1953). The solution of the equations of motion of an electron in axially symmetrical, converging, periodic magnetic fields shows dense beams can be stable in such fields. Periodic focussing is discussed.

621.385.83:[621.317.329+517.944 912

Electrostatic Potential Plotting for Use in Electron-Optical Systems—Kuo-Chu Ho and R. J. Moon. (*Jour. Appl. Phys.*, vol. 24, pp. 1186–1193; Sept., 1953.) A noniterative numerical method is developed for solving a partial differential equation, the boundary conditions of which are not known over the entire closed boundary. This method is used to calculate the shapes of beam-forming electrodes for a rectilinear flow. Complete agreement is obtained with Pierce's experimental results (4275 of 1940) and with the results of electrolyte-trough determinations.

621.385.832:621.317.32 913

Measurement of Voltage using a Simple Electron-Beam Valve—Lieb. (*See* 798.)

621.385.832:621.318.572 914

The E1T Decade Counter Tube—(*Elec. Appl. Bull.*, vol. 14, pp. 71, 76; May, 1953.) Corrections and addendum to paper noted in 603 of February.

621.385.832.002.2 915

The Production of Emiscope Cathode-Ray Tube Gun-Assemblies—(*Machinery*, (*Lond.*), vol. 83, pp. 555–563 and 795–800; Sept. 18 and Oct., 23, 1953.)

621.385.832.002.2:681.142 916

Cementing Metal Screens to Cathode Ray Tubes—R. W. Holmes. (*Mater. and Meth.*, vol. 38, pp. 184, 186; Sept., 1953.) The method described was used for fixing fine mesh screens externally to the screens of cr-tube storage units for the AVIDAC digital computer.

621.385.832.012 917

Experimental Determination of the Characteristic-Curve Index in Cathode Ray Tubes.—E. Gundert. (*Z. angew. Phys.*, vol. 5, pp. 340–341; Sept., 1953.) The cathode current J_k in a triode gun is related to the control grid voltage U_g by the equation $J_k = K(U_g - U_{sp})^n$ where U_{sp} is the value of U_g for $J_k = 0$. Logarithmic plotting presupposes a knowledge of U_{sp}, which, owing to the Maxwell electron velocity distribution, is not easily determined. A formula is derived from which n can be calculated by substituting the values of U_g corresponding to three values of J_k in geometrical progression. For cathode currents up to about 100 μA, $n \approx 2.5$.

621.387.032.212:621.396.665 918

Gas-Discharge Tubes for Control of Microwave Attenuation—D. H. Pringle and E. J. Whitmore. (*Jour. Sci. Instr.*, vol. 30, pp. 320–323; Sept., 1953.) Details are given of the construction and operation of cold-cathode tubes as attenuators for the 3-cm waveband. Operation depends on the interaction between the microwave field and the electron gas supported by the discharge plasma. Construction is based on that of conventional tr switches; a high-*Q* narrow-band type and a low-*Q* wide-band type are described. Applications to agc and modulator circuits are discussed.

YOUR .5-FOOT SHELF IS NOT COMPLETE

...without these popular classics for engineers...published in profusion by the Technical Information Service of Helipot Corporation...leading litterateurs of precision potentiometers...as befits the world's largest manufacturer thereof.

Accuracy of Potentiometer Linearity Measurements by Robert McDonald and Irving Hogan...reprint of a research report originally published in the August 1953 issue of Tele-Tech & Electronic Industries... a study revealing that calculated linearity-error values are far less reliable than previously believed. *Ask for Data File No. 406A*

Characteristics of Precision Servo Computer Potentiometers by Donald C. Duncan...reprint of a talk presented at the American Institute of Electrical Engineers Conference on Feedback Controls Systems. *Ask for Data File No. 406B*

Computing with Servo-driven Potentiometers by F. R. Bradley and R. D. McCoy... reprinted from Tele-Tech & Electronic Industries ...an examination of linearity and loading effects in analog systems... showing how errors may be eliminated...practical circuit techniques ...restriction of potentiometer range, preloading, unloading with feedback amplifiers. *Ask for Data File No. 406C*

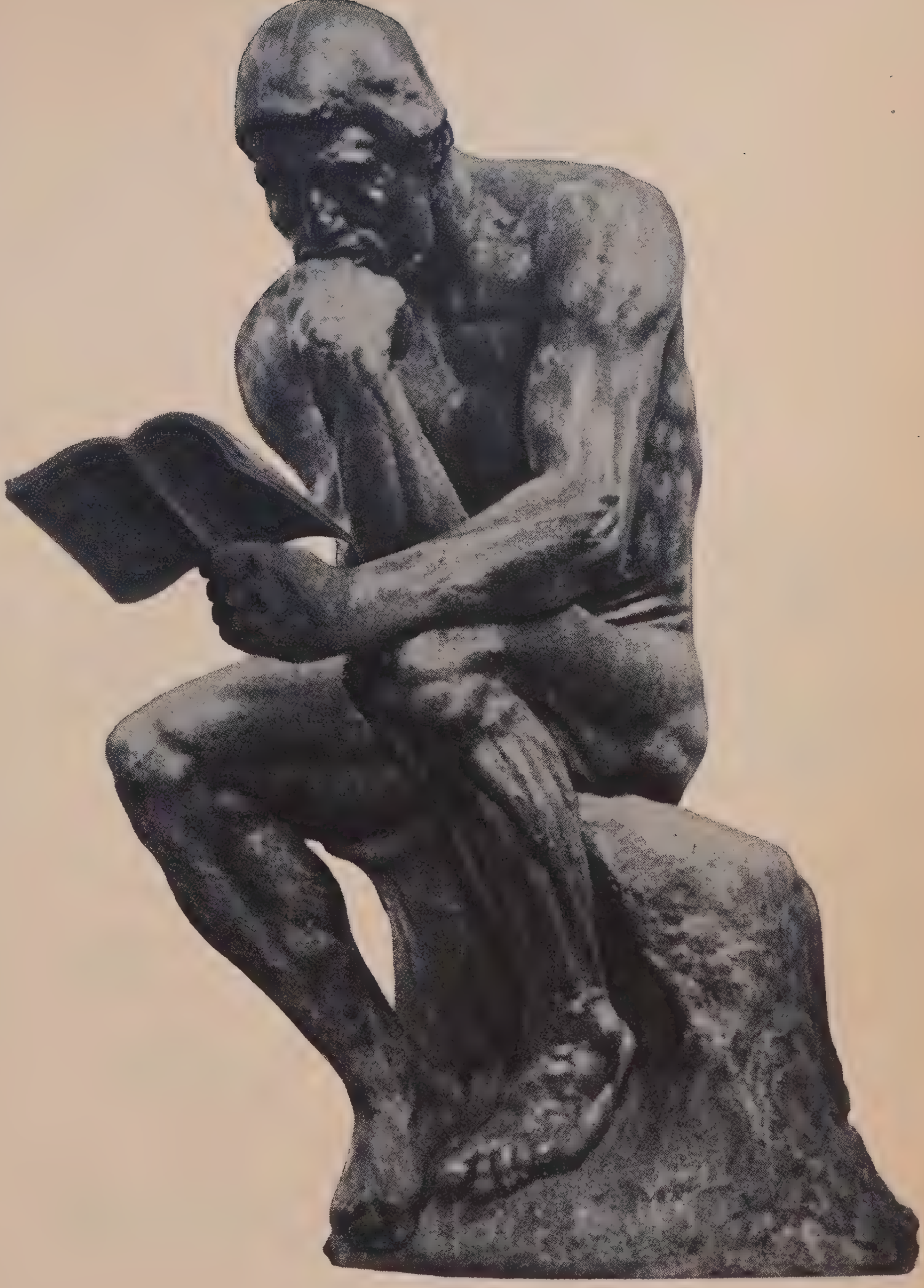
Electrical Noise in Wire-wound Potentiometers by Irving J. Hogan... reprint of a talk presented at the 1952 West Coast I.R.E. Convention...classification of noise by origin, methods of observing and measuring, system of units for expression of noise values. *Ask for Data File No. 406D*

Helipot Condensed Catalog...describes every model of Helipot* precision potentiometer and turns-counting Duodial...includes quick-comparison table of specifications for all series. *Ask for Data File No. 406E*

Helipot Model Selector...this handy device enables you quickly to determine the electrical and mechanical characteristics of all Helipots ...provides easy reference to frequently used electrical data. *Ask for M.S. No. 406F*

*T.M. REG. U.S. PAT. OFF. • 275

HELIPOT *makes a complete line of single-turn and multi-turn precision potentiometers, and turns-counting* DUODIALS. *Many models are regularly carried in stock for immediate shipment.*



ADAPTED FROM THE THINKER BY RODIN

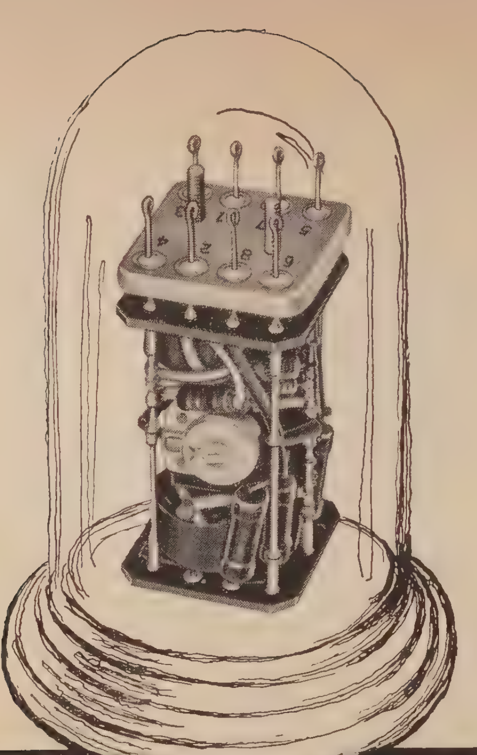
Helipot corporation

a division of BECKMAN INSTRUMENTS, INC.

SOUTH PASADENA, CALIFORNIA

PLANTS AT SOUTH PASADENA & MOUNTAINSIDE, NEW JERSEY
ENGINEERING REPRESENTATIVES IN PRINCIPAL CITIES

first in precision potentiometers

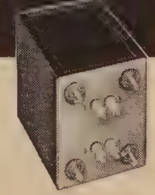


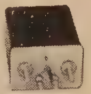
how UNUSUAL can a filter be?

If it's for RF or audio filtering, or harmonic attenuation, or single side band and telemetering equipment—or any number of other uses—chances are that it's *not* so unusual. Not so unusual, that is, that B&W filter engineers haven't already run into something similar in their collective 265 years of experience. And the broad range of experience which these engineers possess is matched by the production skill of B&W's manufacturing personnel . . . with a full complement of high-quality, high-capacity test and production equipment at their disposal.

Whether your problems are in the research, design, development, or production stage . . . in electronics, television, computing, radio broadcasting, or radio communications . . . you'll find the complete facilities of Barker & Williamson ready, willing and able to solve them.

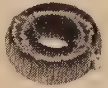
Write now for complete information on B&W filter manufacturing facilities.


BAND-PASS FILTERS


TRAPS

LOW-PASS FILTERS

DISCRIMINATORS


TOROIDAL COILS

HIGH-PASS FILTERS

BAND SUPPRESSION FILTERS

Barker & Williamson is proud to announce that it is now operating the new Boesch Subminiature Toroidal Coil Winding Machine, and invites your inquiries in this new field of effort.

B&W Barker & Williamson, Inc.
237 Fairfield Ave., Upper Darby, Pa.

Industrial Engineering Notes

MOBILIZATION*

A directive recently issued by Donald A. Quarles, Assistant Secretary of Defense for Research and Development, formally established a Technical Advisory Panel on Electronics, plus panels in a number of other fields. The Electronics Panel, headed by Dr. E. W. Engstrom, Vice President in Charge of the RCA Laboratories Division, but not as yet staffed, is provided to insure that the nation's best scientific and technical talents are applied to the planning and prosecution of the military research and development programs on electronics. . . . **Robert B. Murray, Jr., Under Secretary of Commerce for Transportation, has announced a reorganization of the Air Navigation Development Board to enable it to keep pace with rapid developments in military and civil aviation, especially to cope with such problems as procurement planning, installation and operation of aids to navigation and air traffic control.** The first major job of the Board is the evaluation of a short-distance navigation system (TACAN) which now is under development by the military. This system provides the pilot with the same type of continuous bearing-and-distance navigational information which is provided by the present system of VHF Omni Ranges and Distance Measuring Equipment. . . . **As another step in its program to integrate the electronics activities of the military services, an Applications Engineering Co-ordinating Committee on Electronics was authorized recently.** In orders signed by Frank D. Newbury, Assistant Secretary of Defense (Applications Engineering), committees also were established to work in the fields of guided missiles and ordnance, both of which touch on electronics to some extent. The committees on both electronics and guided missiles will be under the chairmanship of William H. Martin, Deputy Assistant Secretary of Defense (AE). Mr. Martin previously had been named a member of the Research and Development Co-ordinating Committee on Electronics, so will serve further to co-ordinate the work of the two groups.

TECHNICAL

The Office of Technical Services, Department of Commerce, in its December issue of the "Bibliography of Technical Reports," includes several research studies in the electronics field. The following, of interest to the electronics industry, can be purchased from the Photoduplication Section, Library of Congress, Washington 25, D. C., for the reported price: "Calculation of the Attenuation of Electric Field Strength," PB 112013, microfilm, $2.50; photostat, $6.25. "Effective Bandwidth of Video Amplifiers," PB 110728, microfilm, $2.25; photostat, $5. "Radio Interference Suppressors," PB 112016, microfilm, $6.25;

(Continued on page 68A)

---

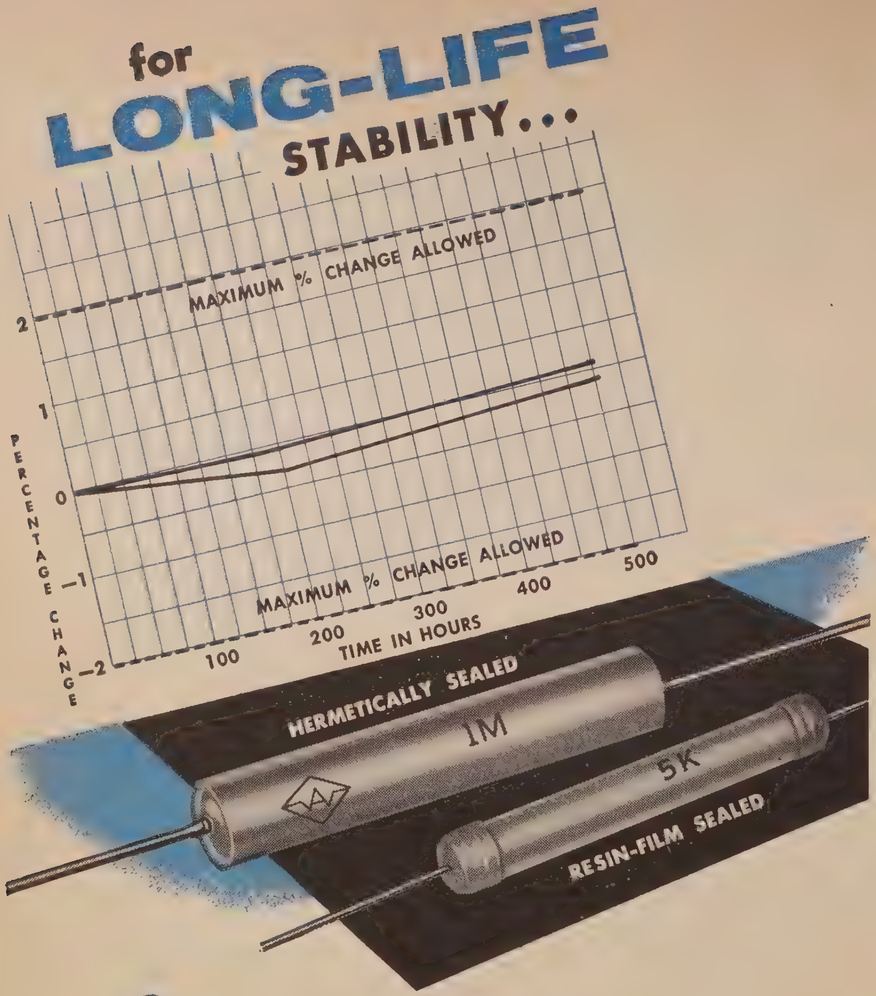
* The data on which these NOTES are based were selected by permission from *Industry Reports*, issues of January 25, February 1, 8, and 15, published by the Radio Electronics Television Manufacturers Association, whose helpfulness is gratefully acknowledged.

ACTUAL SIZE

Now . . . long-awaited *silicon junction diodes* are available; developed by Texas Instruments, a leading transistor manufacturer. Operating temperatures up to 150°C are safe, offering a new degree of design freedom!

New . . . extremely low back current characteristics, as low as 0.001 microamps at rated voltage. Glass-to-metal hermetic seals, of course. For more detailed information on these new silicon junction diodes — and on other new TI semiconductor products — write today.

TEXAS INSTRUMENTS
INCORPORATED
6000 LEMMON AVENUE DALLAS 9 TEXAS



Carbofilm

PRECISION RESISTORS

FUNCTION FITTED

And it's precision that lasts! Accompanying chart reports load-life test on five Type CPH ½ watt (metal-cased) Carbofilm Resistors. Note that all five samples stay well within ±0.25% after 500 hours.

The guaranteed tolerance of Carbofilm Resistors is ±1%. Excellent stability re. temperature and voltage coefficients, overload, ageing, noise, etc. Made under Western Electric patents, these resistors provide the dependability of wire-wounds with the compactness of carbons.

In two types: Coated (special resin film) units for economy as well as accuracy and stability. Hermetically-sealed (metal-cased with glass-to-metal sealing) units for extraordinary protection. Both types in ½, 1 and 2 watt sizes.

Get the FACTS — Engineering literature on request. Let our precision-resistor specialists collaborate on your precision-resistance problems.

AEROVOX CORPORATION
OLEAN, N. Y.
Hi-Q Capacitors WILKOR Resistors

HI-Q DIVISION

AEROVOX CORPORATION NEW BEDFORD, MASS.
ACME ELECTRONICS, INC. MONROVIA, CALIF.
CINEMA ENGINEERING CO. BURBANK, CALIF.

In Canada: AEROVOX CANADA LTD., Hamilton, Ont.

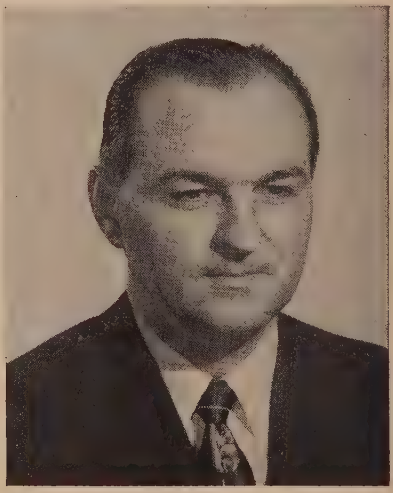
Industrial Engineering Notes

(Continued from page 66A)

photostat, $21.25. "Development of Subminiature High-Temperature Capacitors," PB 112003, microfilm, $2.75; photostat, $7.50. "Magnetostriction and Electrostriction Transducer Delay Lines," PB 112082, microfilm, $3; photostat, $8.75. "Potential Analogue in Network Synthesis and Analysis," PB 110967, microfilm, $2; photostat, $3.75. "Techniques for Application of Electron Tubes in Military Equipment," PB 112329, microfilm, $3; photostat, $8.75. The following research reports are available from the Office of Technical Services, Department of Commerce, Washington 25, D. C., in mimeograph form, for 50 cents a copy: "Fast Response with Magnetic Amplifiers," PB 111212; "Radio-Frequency Circuit for Use in the 300 to 1,000 Megacycle Range," NRL R 4217; "An Automatic Impedance Recorder for X-Band," PB 111231; "Bench-type Signal Tracer," PB 111230; "Design of Fire Control Optics. Vol. 2: Complete Computations for Fire Control Optical Components and Systems," PB 111192. . . . **The Office of Technical Services, Commerce Department, in its January issue of the "Bibliography of Technical Reports," includes several research studies in the electronics field.** The following reports can be purchased from the Photoduplication Section, Library of Congress, Washington 25, D. C., for the price reported: "Final Engineering Report on Blower, Subminiature, for Spot Cooling of Electronic Components," PB 112350, microfilm, $5; photo-

(Continued on page 70A)

Motorola Appoints New Communications Service Manager



Daniel E. Noble, Vice President in Charge of **Motorola's Communications and Electronics Div.,** recently announced the appointment of John P. Tansey to the position of National Service Manager of that division. Mr. Tansey succeeds Fred Schnell who has been designated Staff Assistant to the Vice President.

COLLINS AUTOTUNES* AND AUTOPOSITIONERS

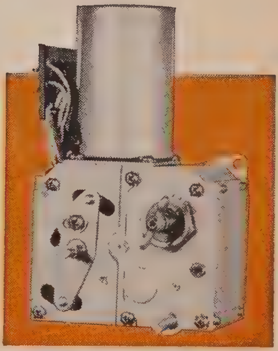
Precision re-positioning devices for application in electronic and industrial equipment requiring accurate multiple channel pre-set control

---

The Collins Autotune has long been the basis for both remotely and directly controlling automatic tuning of high quality, military and commercial communication equipment. It is also applicable to the design of many other industrial and electronic equipments. Variable pre-set positions are chosen by the operator — when once set, the Autotune automatically returns to the selected position with an accuracy unmatched by any other means.

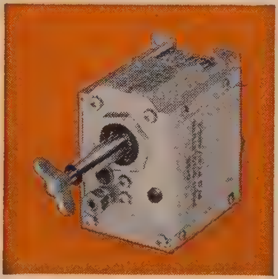
Collins

PACKAGED AUTOTUNE — automatic repositioning device suitable for many applications in industrial control and radio equipment . . . positions one shaft or multiple shafts.

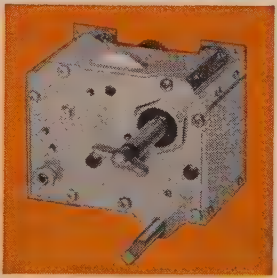


Collins

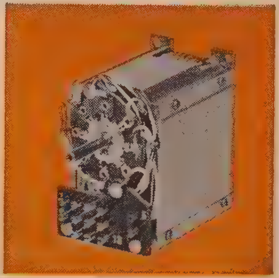
AUTOTUNE SYSTEM COMPONENTS — for variable pre-set positioning of multiple shafts incorporating several Autotunes driven by one motor.



Singleturn Autotune Head



Multiturn Autotune Head



Autotune Control Unit

Collins

AUTOPOSITIONER — for use where up to 20 or more pre-determined fixed positions are needed. Both packaged and individual Autopositioners are available.

For complete information on Collins Autotunes and Autopositioners, contact the nearest Collins office. You will receive prompt attention.

*Reg. U.S. Pat. Off.

COLLINS RADIO COMPANY Cedar Rapids, Iowa

11 W. 42nd Street, NEW YORK 36

1930 Hi-Line Drive, DALLAS 2

2700 W. Olive Avenue, BURBANK

NEW **Berkeley** 1 MEGACYCLE– 1 MICROSECOND

Universal Counter & Timer

Four extended-range precision instruments at the size and price of one! Drives digital printer, IBM card punch converter, or digital-to-analog converter!

Berkeley's new Model 5510 Universal Counter and Timer provides the functions of counter, time interval meter, events-per-unit-time meter and frequency meter in one compact instrument. It will:

① Count at speeds to 1,000,000 counts per second.

② Count events occuring during a selectable, precise time interval.

③ Measure time intervals in increments of 1 microsecond over a range of 3 microseconds to 1,000,000 seconds.

④ Determine frequencies and frequency ratios, from 0 cps to 1 megacycle.

⑤ Provide a secondary frequency standard (stability, 1 part in 10^6).

⑥ Operate directly into (a) the new Berkeley Model 1452 single-unit printer, (b) Berkeley digital-to-analog converter, or (c) Berkeley data processer driving IBM card punches, electric typewriters, or teletype systems.

CONDENSED SPECIFICATIONS

Input Sensitivity: 0.2 v. rms (Freq. meas.); 1.0 v. peak to peak (other functions)
Input Impedance: 10 megohms shunted by 35 mmf.
Time Bases: 1 mc; 100, 10, and 1 kc; 100, 10 and 1 cps.
Gate Times: .00001, .0001, .001, .01, 0.1, 1.0 and 10 seconds
Crystal Stability: 1 part in 10^6 (temp. controlled)
Display Time: 0.2 to 5 seconds
Accuracy: ± 1 count, ± crystal stability
Power Requirements: 117 v. (± 10%), 50-60 cycles, 400 watts
Dimensions: 20¾" wide x 10½" high x 15" deep; panel, 8¾" x 19"
Price: Model 5510, $1,100.00 (f.o.b. factory).

Available for prompt delivery. Wire or write for technical bulletin, application data (see opposite page); please address dept. N4-1

M32

Berkeley *division*
BECKMAN INSTRUMENTS INC.
2200 WRIGHT AVE., RICHMOND, CALIF.

Industrial Engineering Notes

(Continued from page 68A)

stat, $16.25. "Investigation of Radio Receiver Noise Reducing Circuitry,"—Part 1, PB 112347; Part 2, PB 112350. Both are priced: microfilm, $2; photostat, $3.75. "Physical Characteristics of the Lower E-region as Deduced from the Measurement of Changes in Phase Path of Long Radio Waves," PB 112375, microfilm, $4.25; photostat, $12.50. "Considerations of Equal Energy Pattern Over Curved Earth," PB 112000, microfilm, $2; photostat, $3.75. "Low-Frequency Propagation in an Exponential Ionospheric Layer," PB 112141, microfilm, $2; photostat, $3.75. "Development of Lightning Protective Methods and Related Radio-Interference Reduction for Aircraft,"—2nd Report, PB 112348, microfilm, $2.25; photostat, $5; 4th Report, PB 112353, microfilm, $2; photostat, $3.75. "Development and Application of Automatic Assembly Techniques for Miniaturized Electronic Equipment," Phase II, PB 112383, microfilm, $2.75; photostat, $7.50; Phase II (interim report No. 3), PB 112385, microfilm, $2.25; photostat, $5. "Diffraction of Pulses by Parabolic Cylinders and Paraboloids of Revolution," PB 112219, microfilm, $2; photostat, $3.75. "Certain Transmission and Reflection Theorems," PB 112220, microfilm, $1.75; photostat, $2.50. . . . **The U. S. Army Signal Corps announced recently that an automatic punch press with an electronic brain has been developed by General Electric Co. scientists at the Company's Electronics Laboratory at Syracuse, N. Y., and its techniques are being adapted to electronic equipment fabrication under a Signal Corps contract.** Described as "one more step toward the automatic factory of the future" in talks presented at a recent IRE Symposium on automation, the automatic assembly system will place from 10 to 50 standard components, such as resistors and subminiature tubes, on printed wiring boards at a rate of 30 per minute. The final system will provide for preparation and testing of components, for transporting them to the assembly machine, and for soldering and testing the completed sub-assemblies. The automatic assembly system, the Signal Corps reported, is not intended to produce completed products such as radar or television, but will produce printed circuit sub-assemblies for electronic equipment, which will be manually combined into complete products. The Signal Corps contract calls for the development of a system of automatic machinery to assemble and test electronic circuit sub-assemblies for various military electronic equipment, it was reported. . . . **The U. S. Atomic Energy Commission recently released for public use 26 patents, including eight in the electronics field.** Non-exclusive, royalty-free licenses on the listed patents will be granted by the Commission as part of its program to make non-secret technological information available for use by industry. Commission-held patents and patents applications released for licensing now total 640. Applicants for licenses

(Continued on page 71A)

Industrial Engineering Notes

(Continued from page 70A)

should contact the Chief, Patent Branch, Office of the General Counsel, U. S. Atomic Energy Commission, Washington 25, D. C., identifying the subject matter by patent number and title. The following patents were released by the AEC on February 3: Method and Apparatus for Focusing Charged Particles, 2,658,150; Bevatron Acceleration Regulation, 2,658,999; Mass Spectrometer, 2,659,822; Ion Selector, 2,660,677; Magnetic Electron Multiplier, 2,664,515; Ion Accelerating and Focusing System, 2,665,384; Light Valve, 2,667,104; Liquid Level Control, 2,667,178.

FCC ACTIONS

Conforming with Congressional direction, the Federal Communications Commission recently issued a proposed order looking toward the establishment of fees to cover the cost of its licensing and other activities. The fees would range from $3 for simple operator permits and applications to $1,500 for type approval application in the broadcasts, ship and citizens radio services. The FCC proposed fees would be applied to license applications as follows: Major broadcast applications, $325; Minor broadcast applications, $50; Safety and Special Radio Services applications, except Amateur, Disaster and Radio, $10; Amateur Civil Emergency Services application, $3; Experimental Services applications, $20; Type acceptance of equipment applications, $100; Type approval of equipment applications filed under Part 18 of the rules, $600; Applications for type approval covered by Parts 3, 8, or 19 of the rules, $1,500; Commercial operator license applications (all), $3; Restricted radiotelephone operator permit applications, $3; Compulsory ship inspection applications, $30; Applications for telephone acquisitions, consolidations, etc., $350; Applications for construction or extension of telephone lines, $150; Applications by common carriers for exemptions from Commission jurisdiction under Title II, $150; All other common carrier applications (except those covered in fees for the Safety and Special Radio Services), $30. . . . **Responding to a request of the RETMA Microwave Section and Committee TR-14 of the Engineering Department, the Federal Communications Commission recently advised the Association that it planned to establish in the near future an all-industry ad hoc committee to study the microwave field.** The FCC informed RETMA that it contemplated establishing a joint study group "for the purpose of considering microwave rules and standards, and that such group will be composed of representatives of the manufacturers, users, the engineering consultants, and the Commission." In accepting the RETMA offer of assistance the Commission in turn asked for considerable engineering data which would be studied prior to the formation of the ad hoc group. "It would be greatly appreciated," the FCC said, "if RETMA would tabulate and furnish the

(Continued on page 72A)

HOW Berkeley EQUIPMENT HELPED SOLVE A PROBLEM

FOR KILBURG CORPORATION

SAN MATEO, CALIFORNIA

PROBLEM: To determine opening and closing time of dial telephone contacts to an accuracy of 1/100,000 second, when operated by Kilburg "Dialaphone" automatic dialing system.

SOLUTION: Use of a BERKELEY Time Interval Meter capable of measuring opening, closing and operating time to an accuracy of 1/100,000 second. External selector permits measurement of opening and closing time of any single pulse in the chain of pulses generated by operating the telephone dial. Results are displayed digitally in 1/100,000-second increments for rapid, error-free reading.

RESULTS: The president of the James Kilburg Corporation states that precise data obtained by use of the BERKELEY equipment speeded evaluation of the "Dialaphone" system, with savings in time valued at more than $10,000. Its simplicity, reliability, accuracy, and speed also permit substantial savings in production-line testing of the "Dialaphone," an instrument used with standard dial phones which automatically dials any number selected from an alphabetical index included with the unit.

MAY WE HELP SOLVE YOUR PROBLEM? If it involves faster, more accurate, easier and simpler ways to measure frequency, flow, pressure, velocity, rpm., time intervals, viscosity,—or high speed counting and counting plus pre-set control—chances are that BERKELEY can help you solve it. Complete data sheets covering many applications in these fields are yours for the asking—check the handy coupon below and mail it now!

M-26

Berkeley *division*

BECKMAN INSTRUMENTS INC.

2200 WRIGHT AVE., RICHMOND, CALIF.

Dept. N4 2200 Wright Ave., Richmond, Calif.

Please send me application data sheets checked

Name__________

Title__________

Address__________

City__________State__________

MEASUREMENT OF:

☐ Flow ☐ Velocity

☐ Pressure ☐ RPM

☐ Viscosity ☐ Operating Time

☐ Frequency of__________

☐ **COUNTING OR PREDETERMINED COUNTING OF:**

____

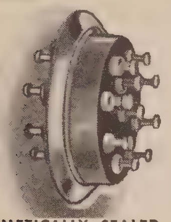
CONTROL OF:

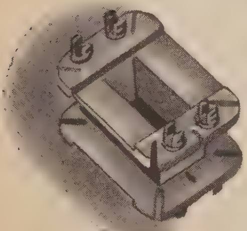
☐ Cutting Stock to Length

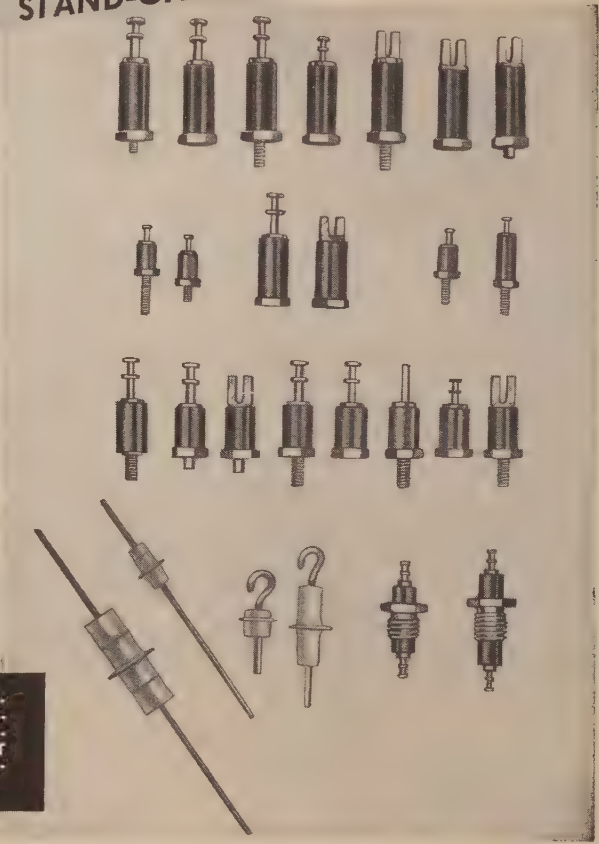
☐ Packaging and Batching

For { HIGH FREQUENCY / HIGH VOLTAGE } Space Saving Applications

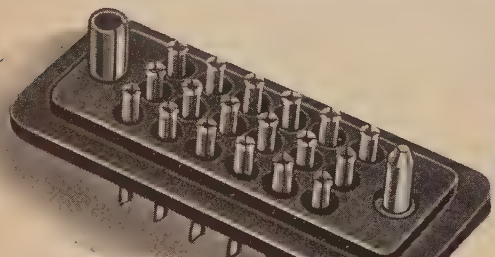
GARDE Miniature & Sub-Miniature
INSULATED STAND-OFFS & FEED THROUGHS


HERMETICALLY SEALED HEADERS


COIL FORMS



CHOICE OF INSULATION CHARACTERISTICS IN ACCORDANCE WITH LATEST Mil-P-14 SPECIFICATIONS.


MULTIPLE TERMINAL CONNECTOR HEADS

BARRIER STRIPS

For users to properly assess the outstanding features and advantages of Garde Components, samples will be sent on request. A detailed technical catalog is now in preparation. Be sure your name is on our mailing list.

We have complete facilities to accommodate your special requirements, ranging from Engineering Consulting Service to Precision Design and Production.

GARDE MANUFACTURING COMPANY
MOLDERS OF THERMOPLASTIC AND THERMOSETTING MATERIALS
588 Eddy Street, Providence 3, Rhode Island -- Sales Representatives in Principal Cities

Industrial Engineering Notes

(Continued from page 71A)

Commission, with respect to each microwave communication frequency band presently in use above 890 megacycles, the critical operating characteristics of the various equipments now installed and available, from the standpoint of possible mutual interference between stations or equipments. . . . **The Federal Communications Commission recently finalized numerous amendments to parts 7 and 8 of its maritime rules which are expected to improve the maritime mobile service of telephony in the frequency band 2000–3000 kc.** The amended rules become effective March 15, 1954. The amendments define more precisely the use permitted of the radio-telephone calling and distress frequency 2182 kc in accordance with treaty provisions; provide for the first substantial increase in the number of public service ship-shore telephone circuits since 1934; and provide for a new intership frequency 2830 kc available for assignment beginning March 15 for use in the Gulf of Mexico area in place of the frequency 2738 kc now shared between the Gulf, the Mississippi River System, the Atlantic and the Pacific areas. The ultimate effect of the amended rules is to include the provision of additional ship-shore public telephone circuits at Boston, New York, Miami, Tampa, New Orleans, Los Angeles (San Pedro), San Francisco, Portland, Ore., and Seattle.

TELEVISON

In answer to a proposal by Telechrome, Inc., Long Island, N. Y., asking that approval be given for the simultaneous transmission of color test signals with the normal black and white program broadcast, the Federal Communications Commission recently stated that as far as the FCC Rules are concerned there are no prohibitions against such transmissions, since color transmission rules became final on January 22. The Commission did state, however, that such test transmission will pose certain problems, since a "sufficient number of lines must be appropriated from the picture to give substantial body to the test color bars . . . and 10 to 12 lines at the top and bottom of the picture would, of course, represent a loss of approximately five per cent in picture resolution." Telechrome's theory was that such simultaneous transmissions "would increase the time available for adjusting color receivers from the present few 'off time' hours to the entire broadcast period; thus a standard of comparison for color would be available whenever needed." The FCC's reply further stated that "although the present position of the NTSC in this matter is unknown, it is apparent from the record that the matter of simultaneous transmission of both color and monochrome was not contemplated." . . . **Seven applications for microwave relay construction permits for new stations were filed last week with the Federal Communications**

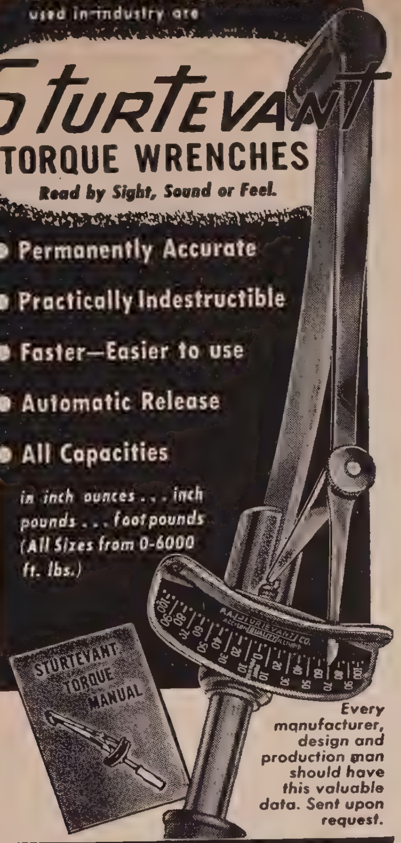
(Continued on page 74A)

Over 85% of the torque wrenches used in industry are

STURTEVANT
TORQUE WRENCHES
Read by Sight, Sound or Feel.

- Permanently Accurate
- Practically Indestructible
- Faster—Easier to use
- Automatic Release
- All Capacities

in inch ounces . . . inch pounds . . . foot pounds (All Sizes from 0-6000 ft. lbs.)



Every manufacturer, design and production man should have this valuable data. Sent upon request.

P. A. STURTEVANT CO.
ADDISON QUALITY ILLINOIS

PRD

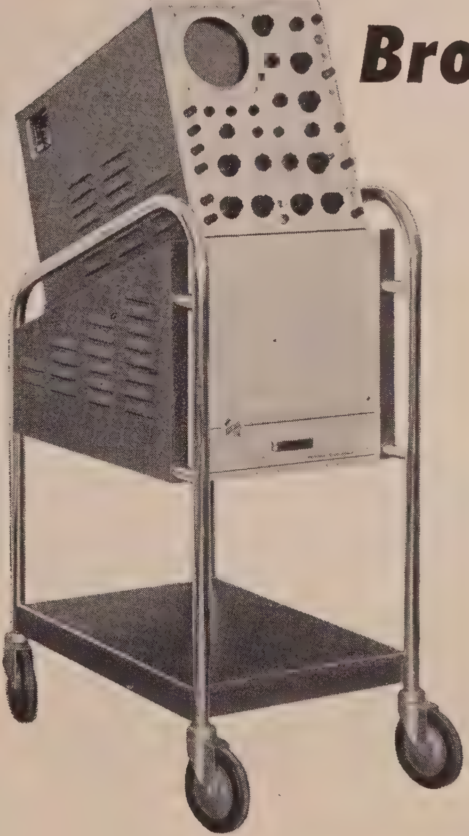
TYPE 904
VHF-UHF
NOISE
GENERATOR

FREQUENCY RANGE (mc/sec): **10 to 1000**
NOISE FACTOR RANGE (db): **20**
CHARACTERISTIC IMPEDANCE: **50 ohms (unbalanced)**

This calibrated broadband noise source permits direct measurements of noise factors as high as 20 db for r-f amplifiers and receivers operating in the range from 10 to 1000 mc/s. Equipment is housed in an attractive metal cabinet.
Write for Catalog

Polytechnic
RESEARCH & DEVELOPMENT CO., Inc.
55 JOHNSON ST., BROOKLYN 1, N.Y.
West Coast:
741 N. Seward St., Hollywood 38, Cal.

Designed for
TELEVISION
Broadcasters



Type 524-D and Scope-Mobile

Sync Separator
Permits triggering from composite signal.

Delayed Sweeps
Zero to 25 milliseconds from start of field—triggered at any selected line.

Field Selector
Instant shift to opposite field.

New Sweep Magnifier
3x or 10x magnification — expands sweep to left and right of center.

Flat Faced CRT
4 kv accelerating potential.

Time Base Range
0.01 sec/cm to 0.1 μsec/cm continuously variable, accurate within 5%.

Transient Response
Risetime — 0.04 μsec.

Direct Coupled
Sensitivity dc to 10 mc — 0.15 v/
to 50 v/cm . . . 2 cps t
0.15 v/cm to 50

Signal D

For a true picture of circuit beha
Type 524-D Television S
ment was designed
tures you need
adjustm
equip

a
perimental
ges of direct coup-
ent transient response,
me base range in a portable
de-ray oscilloscope.

Output
served are brightened
mor.

Cycle Sweep
Separate phase and amplitude controls.

Regulation
All dc voltages electronically regulated.

TO YOUR ADVANTAGE!

Yes, it will be to your definite advantage to attend the IRE Region 7 Technical Conference and Trade Show, Portland, Oregon.
May 5—6—7

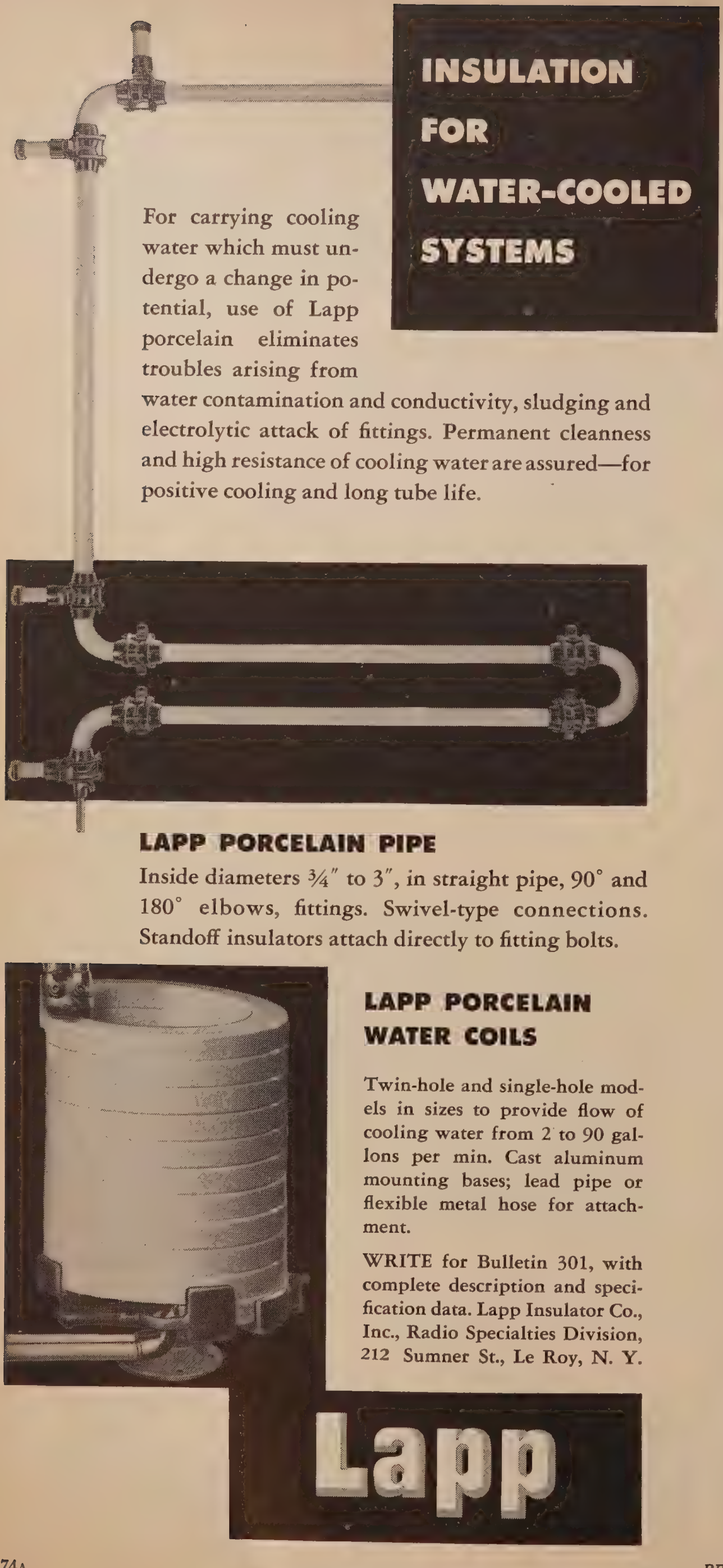
PAPERS BY NATIONALLY PROMINENT MEN!
COMBINE VACATION WITH CONFERENCE ATTENDANCE!
A "RADIO ENGINEERING SHOW" IN MINIATURE!
REMEMBER
PORTLAND, OREGON — MAY 5-6-7

Type 524-D—$1180 f.o.b. Portland, Oregon

Pictured above with the Type 524-D, the TEKTRONIX Type 500 Scope-Mobile — $97.50 f.o.b. Portland, Oregon.

For complete specifications call your TEKTRONIX Field Engineer, or write to:

TEKTRONIX, Inc.
P. O. Box 831B, Portland 7, Oregon • Cable: TEKTRONIX



INSULATION FOR WATER-COOLED SYSTEMS

For carrying cooling water which must undergo a change in potential, use of Lapp porcelain eliminates troubles arising from water contamination and conductivity, sludging and electrolytic attack of fittings. Permanent cleanness and high resistance of cooling water are assured—for positive cooling and long tube life.

LAPP PORCELAIN PIPE

Inside diameters ¾″ to 3″, in straight pipe, 90° and 180° elbows, fittings. Swivel-type connections. Standoff insulators attach directly to fitting bolts.

LAPP PORCELAIN WATER COILS

Twin-hole and single-hole models in sizes to provide flow of cooling water from 2 to 90 gallons per min. Cast aluminum mounting bases; lead pipe or flexible metal hose for attachment.

WRITE for Bulletin 301, with complete description and specification data. Lapp Insulator Co., Inc., Radio Specialties Division, 212 Sumner St., Le Roy, N. Y.

Lapp

Industrial Engineering Notes

(Continued from page 72A)

Commission by the American Telephone and Telegraph Co., thus providing the second section of the proposed Amarillo-Los Angeles radio relay system. The seven requested CPs are for Los Angeles, Padua Hills, Strawberry Peak, Clise Springs, Sandy, and Turquoise, all California, and Potosi, Nevada.

Federal Personnel

Robert E. Lee, recess appointee as Federal Communications Commissioner, has received Senate approval by a vote of 58 to 25. Mr. Lee, who took office last October, will serve a seven-year term from last July 1 and fills the vacancy created by the retirement of Paul A. Walker.

RETMA Activities

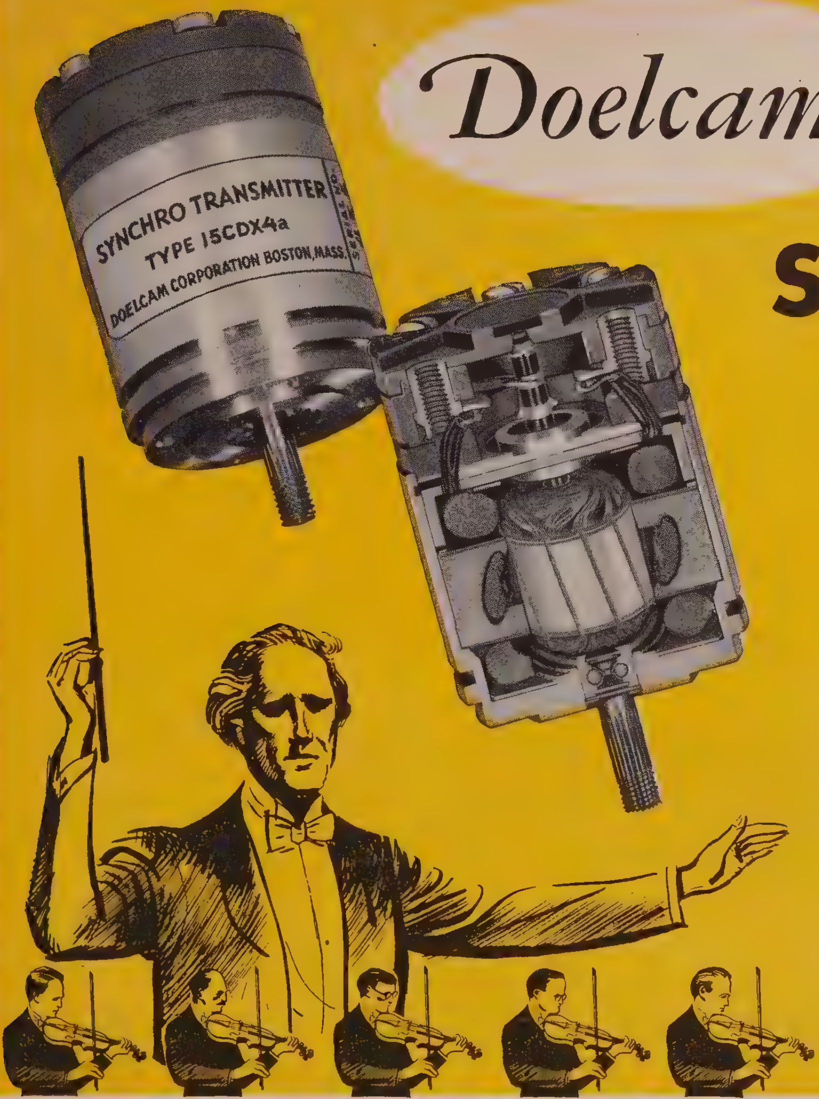
Dissolution of the National Television System Committee, the industry-wide organization of electronic engineers and scientists which developed the color television standards approved recently by the Federal Communications Commission, was announced by its Chairman, Dr. W. R. G. Baker. . . . A technical report on "Color Transcriptions," expected to arouse widespread interest in the television and motion picture industries, has been made available in printed form by one of the technical panels of the National Television System Committee. Dr. Alfred N. Goldsmith of New York City, Chairman of NTSC Panel 11-A, which probed "Color Transcriptions," reported that acceptable color-film records of live programs and color release prints suitable for color television transmission can be produced and satisfactorily transmitted by available materials. Dr. Goldsmith described the panel report as "the first handbook on color transcriptions, their projections and use, from a technical and industrial viewpoint." The 30 members of the technical panel and additional subcommittee members devoted more than 10,000 man-hours to study and to preparation of the report. Copies of the report are available to producers and processors of color TV film, networks or stations planning use of color transcriptions, laboratories producing color film or color film equipment through the office of NTSC Chairman W. R. G. Baker of the General Electric Co., Electronics Park, Syracuse, N. Y.

Aeronautical

Plans to complete construction of a nationwide network of improved air navigation aids were announced recently by the Civil Aeronautics Administration, Department of Commerce. Work is to be completed this year. The present schedule includes completion of the installation of the 327 Distance Measuring Equipments (DME), already on the sites, in addition to the 122 DME's now in operation, and completion of 4-Very High Frequency Omniranges (VOR) to round out coverage now provided by 378 installations.

(Continued on page 76A)

to follow the leader – *precisely* – specify



Doelcam

Synchros

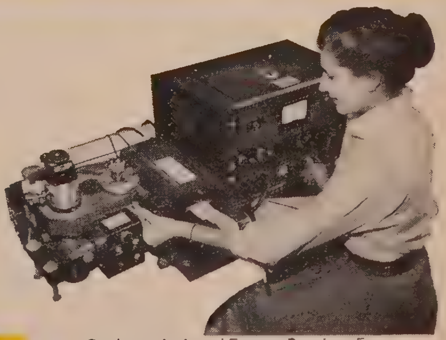
PERFECTION of detail is the difference between a good performance and the very finest — like the coordinated attack and release of a brilliant string section. The precision with which DOELCAM Synchros transmit and receive electrical information is unsurpassed in a precision industry.

DOELCAM Synchros are tested and perfected standard military components for use in servomechanisms, computers, and automatic control systems. Many thousands have been delivered under Prime Government Contracts, which until recently absorbed our entire output. Now, the added facilities of our new plant enable us to make these outstandingly precise units available for general military and industrial usage. Your inquiry is invited.

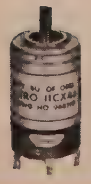
**Write for
Bulletin S16**

SIZES and Excitation	TYPES Control Transmitters	TYPES Control Transformers	TYPES Torque Transmitters	TYPES Torque Receivers
SIZE 11 1.062" O.D. 115v 400 Cycles	11CX4a	11CT4a		
SIZE 15 1.437" O.D. 115v 400 Cycles	15CX4a 15CDX4a	15CT4a	15TDX4a	15TR4a
SIZE 23* 2.25" O.D. 115v 60 & 400 Cycles	23CX4a 23CX6 23CDX4a	23CT4a 23CT6 23CT6a	23TX4a	23TR4a 23TR6 23TR6a
SIZE 31 3.10" O.D. 115v 60 Cycles			31TX6	

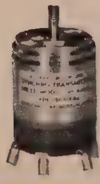
*All Type 23 Synchros are available with keyed or splined shafts.



Doelcam-designed Torque Receiver Error Tester has established an entirely new quality level for Type "TR" Synchros



SIZE 11
1.062" O.D.
Specification
MIL-S-16892 (BuOrd)



SIZE 15
1.437" O.D.
Specification
MIL-S-16892 (BuOrd)

SIZE 23
2.25" O.D.
MIL-S-12472 (ORD)
FXS-1066 (ORD)

SIZE 31
3.10" O.D.
Specification
MIL-S-12472 (ORD)

Doelcam CORPORATION
SOLDIERS FIELD ROAD, BOSTON 35, MASS.
West Coast Office: 304 Tejon Pl., Palos Verdes, Calif.

Instruments for Measurement and Control
Gyroscopic Instrumentation • Servomechanisms
Synchros • Microsyns • Servo Motors

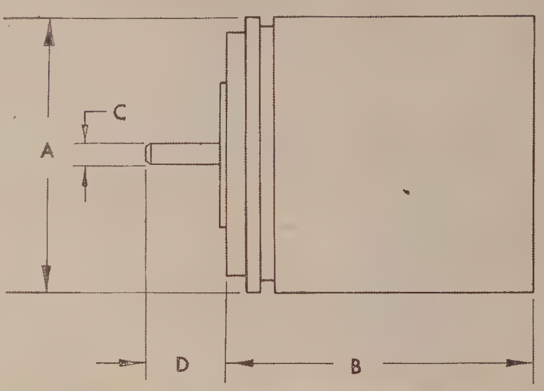
Kearfott developed Servo Motors
. . . in production

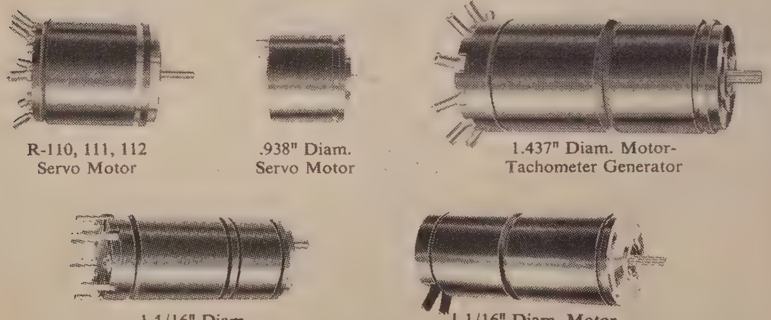
A Navy BuOrd Size 9 to Size 18

B From 25/32" to 1 57/64" long

C Plain Shafts .1200" and .1721" Diam.
Pinion Shafts—13 Teeth 120 Pitch .1247" O.D.
15 Teeth 96 Pitch .1771" O.D.

D Plain Shafts from 5/16" to 1/2" long
Pinion Shafts from 5/32" to 7/16" long





R-110, 111, 112 Servo Motor

.938" Diam. Servo Motor

1.437" Diam. Motor-Tachometer Generator

1 1/16" Diam. Geared Servomotor

1 1/16" Diam. Motor-Tachometer Generator

Shown Approx. 1/2 size

Characterized by very low rotor inertia, low time constants and high stall torque, Kearfott Servo Motors are available for your most exacting requirements. Unitized housing and stator construction makes possible optimum performance under extreme environmental conditions.

For either 26 or 115 volt, 60 or 400 cycle excitation, stall torque values range from .30 to 3.5 oz.-in. Geared Servo Motors in the same diameters can be provided with reduction ratios ranging from 10:1 to 300:1. Various Motor-Generator combinations provide ½ to 3.1 volts per 1000 R.P.M. with linearity, over a speed range of 0-5400 R.P.M., of 1% for damping or .1% for computing purposes.

Send for Bulletin describing Servo Motors of interest to you.

KEARFOTT COMPONENTS INCLUDE:

Gyros, Servo Motors, Synchros, Miniaturized Vacuum Tube and Magnetic Amplifiers, Tachometer Generators, Hermetic Rotary Seals, Aircraft Navigational Systems, and other high accuracy mechanical, electrical and electronic components.

Kearfott
SINCE 1917

KEARFOTT COMPANY, INC., LITTLE FALLS, N. J.
Midwest Office: 188 W. Randolph St., Chicago 1, Ill., West Coast Office: 253 N. Vinedo Ave., Pasadena, Calif.
A General Precision Equipment Corporation Subsidiary

Industrial Engineering Notes

(Continued from page 74A)

INDUSTRY STATISTICS

Over 9.8 million cathode ray tubes and 437 million receiving tubes were sold by manufacturers during 1953, according to a report from the RETMA Statistical Department. Manufacturers' sales of both tube types in December, however, declined from the level of November and of the previous December. During 1953, the Statistical Department reported that 9,839,138 cathode ray tubes worth $234,721,038 were sold by the manufacturers compared with 7,635,666 tubes values at $170,652,078 sold in 1952. Receiving tube sales in 1953 totaled 437,091,555 units with a value of $303,675,313 compared with 368,519,243 tubes worth $259,116,089 sold in 1952.

PROFESSIONAL GROUP MEETINGS

ANTENNAS AND PROPAGATION

The Chicago Chapter of the Professional Group on **Antennas and Propagation** met on November 20, 1953 at the Western Society of Engineers, Chicago, Ill., under the chairmanship of George Kearse. Dr. R. M. Soria of American Phenolic Co., spoke on "Measurements Techniques for UHF TV Receiving."

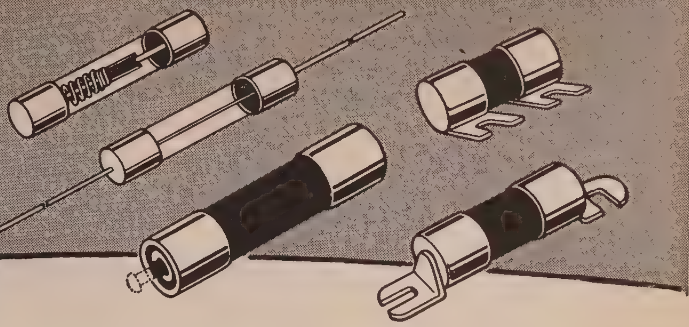
The Albuquerque-Los Alamos Chapter of the PGAP met on January 4, 1953 under the chairmanship of R. B. Jacques. Dr. R. K. Moore, Sandia Corporation, presented a paper on "Antennas in Conducting Media." Some novel problems which arise in mathematical analysis of antennas operated in a conducting medium, such as sea water, were discussed. Failure of the elementary methods for computing input impedance or resistance is due chiefly to the high losses in the immediate vicinity of the antennas. The input impedance to an antenna in a conducting medium is essentially due to current flowing near the antenna and bears little relation to the field at a distance. For this reason, the elementary dipole and isotropic radiator cannot be used as standards since the power loss in their vicinity is a function of their size. Methods for analyzing certain kinds of antennas were shown, and results for loop, biconical, and insulated cylindrical antennas were compared.

AUDIO

The Cleveland Chapter of the Professional Group on **Audio** met on January 26, 1954 at the Case Institute of Technology in Cleveland, Ohio, under the chairmanship of Herbert H. Heller. Otto Kornei of the Clevite Brush Development Co. spoke on "Magnetic Transducer Heads." Mr. Kornei discussed the history of magnetic

(Continued on page 78A)

Why BUSS FUSES give "Trouble Free" Protection

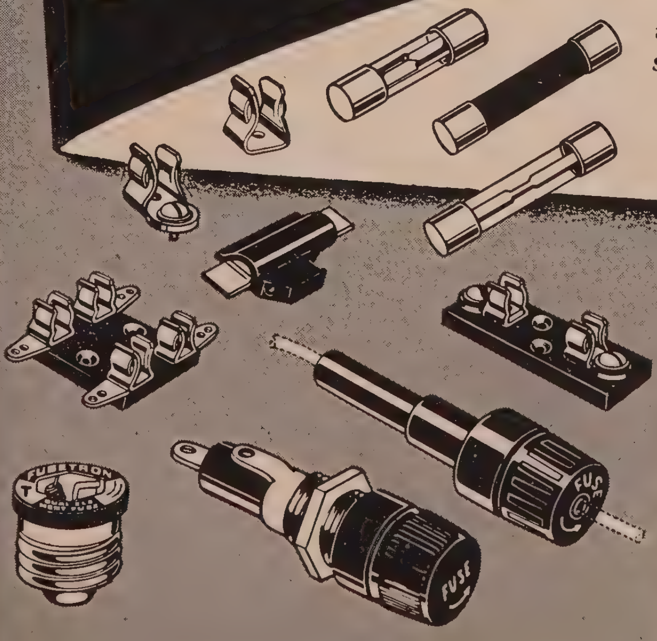


No matter when a BUSS fuse is called upon to operate, you can be sure of dependable and accurate electrical protection. For every BUSS fuse is tested in a sensitive electronic device that rejects any fuse not correctly calibrated, properly constructed and right in all physical dimensions.

This insistence on perfection is the reason manufacturers and service organizations can rely on BUSS as the one source for "trouble-free" fuses.

And by standardizing on BUSS fuses, you can simplify your buying, stock handling and records. The line is complete: standard type, dual-element (slow blowing), renewable and one-time types . . . in sizes from 1/500 ampere up — plus a complete line of fuse clips, blocks and holders.

Should you have a special problem in electrical protection — our fuse research laboratory and its staff of engineers are at your service to help you select the right fuse for the job — and if possible a fuse already available in wholesalers' stocks.



Makers of a complete line of fuses for home, farm, commercial, electronic and industrial use.

FUSETRON
TRUSTWORTHY NAMES IN ELECTRICAL PROTECTION
BUSS

For more information mail this Coupon ▶

BUSSMANN Mfg. Co. (Division of McGraw Electric Co.)
University at Jefferson, St. Louis 7, Mo.

Please send me bulletin SFB containing facts on
BUSS small dimension fuses and fuse holders.

*Name*____________________

*Title*____________________

*Company*____________________

*Address*____________________

*City & Zone*__________ *State*______ IRE-454

2K50
MADE IN U.S.A.
Bendix

Your source for 2K50

REFLEX KLYSTRON TUBES

The new Bendix Red Bank 2K50 is the perfect answer for those who want a thermally-tuned Reflex Klystron tube for K-band operation.

The 2K50 has two primary applications—first, as a local oscillator in small, compact, lightweight, high definition radar and, second, as an oscillator in microwave spectrometers, signal generators and spectrum analyzers.

Because of its thermal feature, the 2K50 may be tuned automatically. Thus, it is ideally suited for difficult locations . . . in aircraft, for example . . . where direct or mechanical tuning is not practical.

Perfection of the complex, ultra-precision 2K50 . . . one of the most difficult electron tubes to manufacture . . . is a tribute to the unique talents of our engineers and production men. It demonstrates why you can depend on Bendix Red Bank for the answer to *any* special-purpose electron tube problem you may have.

MAXIMUM RATINGS

Resonator Voltage	330 volts D.C.
Reflector Voltage	—150 volts D.C.
Tuner Grid Voltage	—50 volts D.C.
Filament Voltage	6.3 ± 8% volts
Gun Cathode Current	28 ma. D.C.
Tuner Cathode Current	10 ma. D.C.

ELECTRICAL CHARACTERISTICS

Heater Voltage (A.C. or D.C.)	6.3 volts
Heater Current	.755 amps.
Thermal Tuning Range	23216 to 24751 Mc/Sec.
Min. Power Output at 23504 Mc/Sec.	8.5 mW.
Min. Power Output at 23984 Mc/Sec.	10.0 mW.
Min. Power Output at 24464 Mc/Sec.	8.5 mW.
Min. Electronic Tuning at Mid-Band	55 Mc/Sec.

PHYSICAL CHARACTERISTICS

• Dimensions: Maximum seated height 2¼" • Base: Small Octal 8-Pin, B8-21, Low Loss Phenolic Wafer • Coupling to Wave Guide: Direct, by means of an insulating fitting • Cooling: Convection • Mounting Position: Any • Cavity: Silver Plated Steel (integral within the bulb) • Bulb: Metal • Output Window: Low loss glass

Bendix Red Bank

Manufacturers of Special-Purpose Electron Tubes, Inverters, Dynamotors and Fractional HP D.C. Motors

DIVISION OF

THE NAME Bendix AVIATION CORPORATION MILLIONS TRUST

EATONTOWN, N. J.

West Coast Sales and Service: 117 E. Providencia, Burbank, Calif.
Export Sales: Bendix International Division, 205 E. 42nd St., New York 17, N. Y.
Canadian Distributor: Aviation Electric Ltd., P.O. Box 6102, Montreal, P.Q.

PROFESSIONAL GROUP MEETINGS

(Continued from page 76A)

recording heads, limitations of the various early shapes leading to the present ring construction. Performance curves under conditions of variable gap width, tape speed, bias current, etc., were explained. Microphotographs of contact surfaces were followed by color slides of the various stages of construction and assembly of Brush "Redheads." After the formal presentation, members brought up problems encountered in the field which were aptly dealt with by the speaker, who has been associated with magnetic recording since before 1933 in Europe.

The Chicago Chapter of the Group met on December 18, 1953 at the Western Society of Engineers, Chicago, Ill., to hear Karl Kramer of the Jensen Manufacturing Co. speak on "Design and Construction of Low Frequency Horns." The Chicago Chapter also met on November 20, 1953 to hear Stanley K. Webster, Beltone Hearing Aid Co., speak on "An All-Transistor Hearing Aid Circuit."

CIRCUIT THEORY

The Chicago Chapter of the Professional Group on **Circuit Theory** met on December 18, 1953 at the Western Society of Engineers Building, Chicago, Ill., to hear Dr. Thomas J. Higgins, Professor of Electrical Engineering at the University of Wisconsin, speak on "Status Quo of Non-linear Circuit Analysis."

At the November 20th meeting of the Chicago Chapter, Professor M. B. Reed of the University of Illinois presented a paper entitled "Foundations of Network Theory."

On September 25, 1953, the Chicago Chapter heard Bernard Parmet of Motorola, Inc., speak on "NTSC Color Television."

COMPONENT PARTS

The Los Angeles Chapter of the Professional Group on **Component Parts** met on December 7, 1953 at the IAS Building, Los Angeles, Calif., to hear James A. K. Richards and Carl McCready speak on "Some Late Results of the BAC/PDDL Tube Processing Program," and "Electron Tube Processing by Equipment Manufacturers as a Method for Obscuring the Facts about Production Efficiency and Reliability," respectively. Bernard Walley, of RCA, was moderator for the program. The following officers were also elected at the meeting: Chairman, Roy E. Colander, Vice Chairman, R. W. Lacey, and Secretary, Eric Swarthe.

The Los Angeles Chapter also met on February 8, 1954 to hear Drs. J. Burnham and C. R. Gates speak on "Tantalum vs. Aluminum Electrolytic Capacitors." Dr. Burnham discussed the advantages and

(Continued on page 80A)

DESIGNED

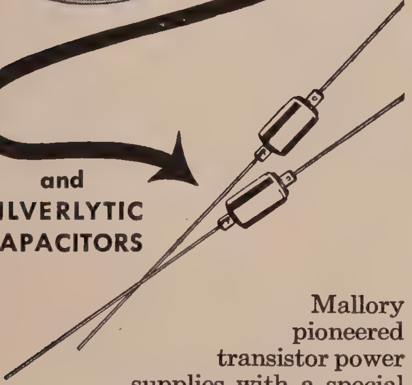
Especially for

TRANSISTOR CIRCUITS

P. R. MALLORY & CO. Inc.
MALLORY

MERCURY BATTERIES

and
SILVERLYTIC CAPACITORS



Mallory pioneered transistor power supplies with a special line of Mercury Batteries that deliver the constant-current, constant-voltage necessary for the best performance of transistor circuits. In addition, Mallory Batteries offer unusually long shelf life and high ratio of energy to size and weight.

Tiny, specially-developed Mallory Silverlytic Capacitors also meet every requirement of low voltage transistor applications.

For complete data, write or call P. R. MALLORY & CO. INC., Indianapolis 6, Indiana.

Available NOW

IN PRODUCTION QUANTITIES

P. R. MALLORY & CO. Inc.
MALLORY

SAR PULSESCOPE

by Waterman

MODEL S-4-C

DIRECT-READING DELAYED SWEEP ACCURATE TO 0.1%

Size:
9⅛" x 11¼" x 17¼"
31.5 Pounds

ANOTHER EXAMPLE OF Waterman PIONEERING...

The SAR PULSESCOPE, model S-4-C, is JANized (Gov't Model No. OS-4), the culmination of compactness, portability, and precision in a pulse measuring instrument for radar, TV and all electronic work. An optional delay of 0.55 microseconds assures entire observation of pulses. A pulse rise time of 0.035 microseconds is provided thru the video amplifier whose sensitivity is 0.5V p to p/inch. The response extends beyond 11 mc. A and S sweeps cover a continuous range from 1.2 to 12,000 microseconds. A directly calibrated dial permits R sweep delay readings of 3 to 10,000 microseconds in three ranges. In addition, R sweeps are continuously variable from 2.4 to 24 microseconds; further expanding the oscilloscope's usefulness. Built-in crystal markers of 10 or 50 microseconds make its time measuring capabilities complete. The SAR PULSESCOPE can be supplied directly calibrated in yards for radar type measurements. Operation from 50 to 400 cps at 115 volts widens the field application of the unit. Countless other outstanding features of the SAR PULSESCOPE round out its distinguished performance.

WATERMAN PRODUCTS CO., INC.
PHILADELPHIA 25, PA.
CABLE ADDRESS: POKETSCOPE

MEMO..
Write for details today!

WATERMAN PRODUCTS INCLUDE

- S-4-C SAR PULSESCOPE®
- S-5-A LAB PULSESCOPE
- S-6-A BROADBAND PULSESCOPE
- S-11-A INDUSTRIAL POCKETSCOPE®
- S-12-B JANized RAKSCOPE®
- S-14-A HIGH GAIN POCKETSCOPE
- S-14-B WIDE BAND POCKETSCOPE
- S-15-A TWIN TUBE POCKETSCOPE
- RAYONIC® Cathode Ray Tubes and Other Associated Equipment

WATERMAN PRODUCTS

MINIATURIZING YOUR EQUIPMENT?

Specify SIMPLEST, MOST COMPACT

AMPERITE

THERMOSTATIC DELAY RELAYS

MOST ECONOMICAL, HERMETICALLY SEALED

Provide delays ranging from 2 to 120 seconds.

- Actuated by a heater, they operate on A.C., D.C., or Pulsating Current.
- *Hermetically sealed.* Not affected by altitude, moisture, or other climate changes.
- Circuits: *SPST only*—normally open or normally closed.

Amperite Thermostatic Delay Relays are compensated for ambient temperature changes from —55° to +70°C. Heaters consume approximately 2 W. and may be operated continuously. The units are *most compact, rugged, explosion-proof, long-lived,* and — *inexpensive!*

TYPES: Standard Radio Octal, and 9-Pin Miniature.

STANDARD MINIATURE

PROBLEM? Send for Bulletin No. TR-81

BALLAST-REGULATORS

- Amperite Regulators are designed to keep the current in a circuit ***automatically regulated*** at a definite value (for example, 0.5 amp).
- For currents of 60 ma. to 5 amps. *Operates on A.C., D.C., Pulsating Current.*
- Hermetically sealed, light, compact, and most inexpensive.

BATTERY VOLTAGE 30 20 10

VOLTAGE OF 24V BATTERY & CHARGER VARIES APPROX. 50% | WITH AMPERITE VOLTAGE VARIES ONLY 2%

T6½L T9 T9 BULB

Maximum Wattage Dissipation: T6½L—5W. T9—10W.

Amperite Regulators are the simplest, most effective method for obtaining ***automatic regulation*** of current or voltage. *Hermetically sealed,* they are not affected by changes in altitude, ambient temperature (—55° to +90°C), or humidity. Rugged; no moving parts; changed as easily as a radio tube.

Write for 4-page Technical Bulletin No. AB-51

AMPERITE CO. Inc., 561 Broadway, New York 12, N. Y.

In Canada: Atlas Radio Corp., Ltd., 560 King St. W., Toronto 2B

PROFESSIONAL GROUP MEETINGS

(Continued from page 78A)

disadvantages of the two types of electrolytic capacitors. Dr. Gates discussed the use and misuse of definitions and Reliability.

ELECTRONIC COMPUTERS

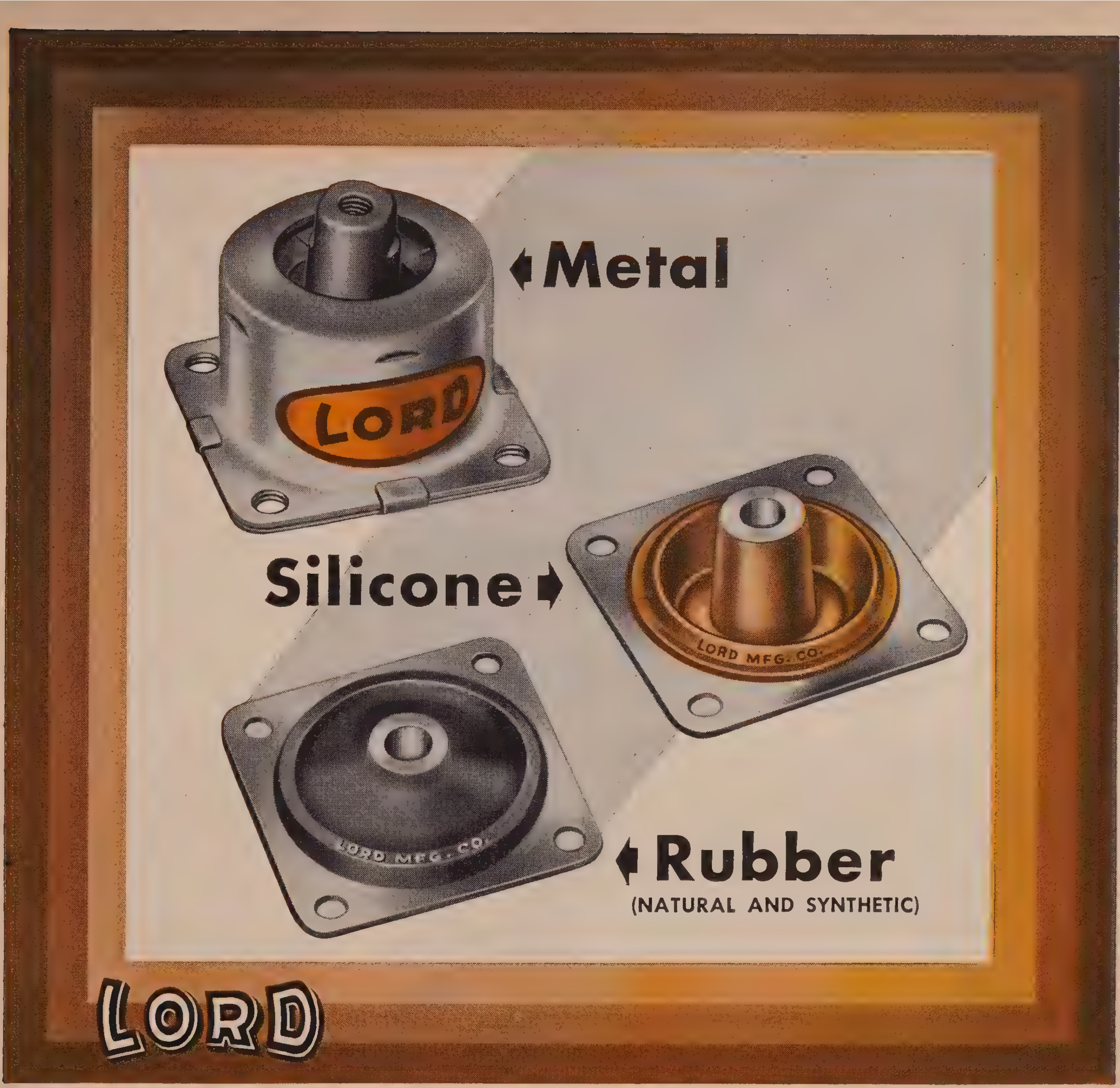
The Los Angeles Chapter of the Professional Group on **Electronic Computers** met on December 17, 1953 at INA-UCLA, under the chairmanship of L. L. Kilpatrick. A summary of the operating and checking features of the Consolidated Engineering 36-101 Computer was presented in the form of four papers: D. H. Raudenbush, "Engineering Features of the CEC 36-101"; R. H. Lawler, "A Survey of the Input System"; J. C. Alrich, "A Brief Outline of the Adder Operation"; and E. R. Quady, "Display Features of the 36-101."

At the November 19th meeting of the Los Angeles Chapter Walter Hockwald of North American Aviation spoke on "Application and Design of D-C Operational Amplifiers for Analog Computers," and Erwin Tomash of Remington Rand spoke on the "Engineering Features of the ERA 1103." Mr. Hockwald presented a detailed description of a standardized D-C amplifier for use in analog computers. This amplifier has a very low drift rate and is designed for maximum reliability and fail-safe operation.

The Philadelphia Chapter of the Group met on January 19, 1954 for a panel discussion on "Design Criteria for Digital-Computer Circuits." The Moderator was I. L. Auerbach, and the discussion leaders were J. Weiner, J. Pomerene, and G. Hoberg. John L. Hill, R. E. Meagher, and N. H. Taylor were the speakers. The first attempt at the Panel Discussion meeting was a great success. The subject matter on design criteria as presented by the three speakers and added to by the three panel discussion leaders was well received by the audience. The technical level was about right, as was the coverage of the subject matter. The audience felt that this method of presenting technical problems and information was excellent.

The Chicago Chapter of the Group met on November 20, 1953 to hear Dr. James E. Robertson of the University of Illinois speak on "Logical Design of Digital Computers." Dr. Robertson spoke on the logic circuits used in digital computers and their relation to mathematics and formal logic. The basic logic circuits AND, OR, and NOT were presented. Their use in an Adder was demonstrated. The Chicago Chapter also met on September 25, 1953 to hear R. J. Klein speak on "Beam Stabilization in Electrostatic Memory Tubes." The paper was discussed by Ted Saltzberg, W. P. Byrnes, and Robert Adler.

(Continued on page 82A)



Recommends Materials Best Adapted to your Vibration Control Requirements

Metal—Natural Rubber—Silicone—Neoprene—Buna S—Buna N—and others are selected by LORD Engineers to satisfy your specific environmental conditions and assure the most economical solution of your vibration control problem.

LORD research is constantly developing and evaluating new materials and processes to insure that the most complete line of vibration control mountings is at your disposal.

LOS ANGELES 28, CALIFORNIA
7046 Hollywood Blvd.

DALLAS, TEXAS
313 Fidelity Union Life Building

PHILADELPHIA 7, PENNSYLVANIA
725 Widener Building

DAYTON 2, OHIO
410 West First Street

DETROIT 2, MICHIGAN
311 Curtis Building

NEW YORK 16, NEW YORK
280 Madison Avenue

CHICAGO 11, ILLINOIS
520 N. Michigan Ave.

CLEVELAND 15, OHIO
811 Hanna Building

LORD MANUFACTURING COMPANY • ERIE, PA.

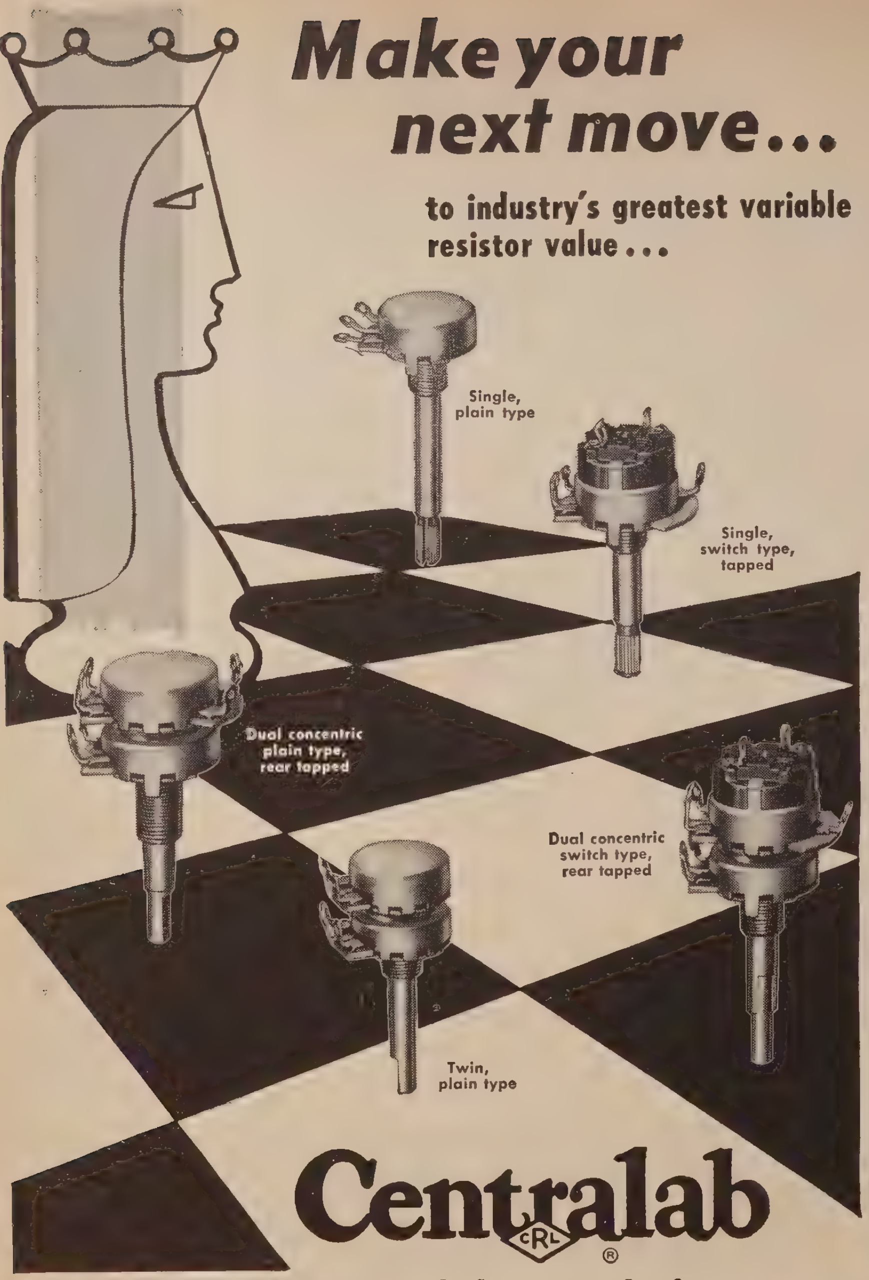
Over 27,000 basic designs and their variations are already available from which to choose.

LORD
BONDED RUBBER

Headquarters for
VIBRATION CONTROL

Make your next move...

to industry's greatest variable resistor value...


Single, plain type
Single, switch type, tapped
Dual concentric plain type, rear tapped
Dual concentric switch type, rear tapped
Twin, plain type

Centralab CRL®

Model 2 Radiohm®

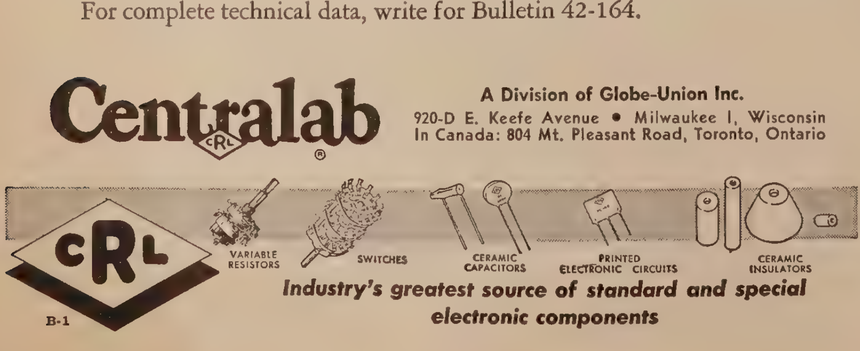
SPECIFY Centralab Model 2 Radiohms — it's a move in the *right direction* to new production simplicity . . . new, finer performance. Model 2's are only 15/16″ in diameter, and rated at ½ watt. You get lower noise level, longer life, more value for your money.

Imagine the larger variety of uses in TV, radio, sound and test applications. Available in two switch ratings — 5 amps @ 125 volts a-c and 8 amps @ 125 volts a-c. There are six different switching combinations for real flexibility and greater circuit simplification.

For complete technical data, write for Bulletin 42-164.

Centralab CRL ®

A Division of Globe-Union Inc.
920-D E. Keefe Avenue • Milwaukee 1, Wisconsin
In Canada: 804 Mt. Pleasant Road, Toronto, Ontario



Industry's greatest source of standard and special electronic components

B-1

PROFESSIONAL GROUP MEETINGS

(Continued from page 80A)

The San Francisco Chapter of the Group met on December 10, 1953 at the University of California at Berkeley under the chairmanship of T. H. Meisling to hear Ascher Opler and Everett Calhoun speak on "Application Requirements for Digital Computing Equipment." The San Francisco Chapter also met on November 4, 1953 to hear a tutorial paper, "Magnetic Recording of Binary Information," presented by Albert S. Hoaglund of the University of California. A panel discussion of "Magnetic Recording for Digital Processing Systems," followed the presentation of the paper.

ENGINEERING MANAGEMENT

The Washington, D. C. Chapter of the Professional Group on **Engineering Management** met on January 25, 1953 at the National Academy of Sciences, under the chairmanship of R. D. Bennett. Professor L. Hattery of American University spoke on "Can Management be Taught." This paper was discussed by the audience, and will be submitted to the PGEM TRANSACTIONS for publication.

MICROWAVE THEORY AND TECHNIQUES

The Chicago Chapter of the Professional Group on Microwave Theory and Techniques met on December 18, 1953 to hear Tore Anderson, Airtron, Inc., speak on "Waveguide Coupled Circuits." The theoretical background of the four basic coupler structures, Dethe hole, Schwinger reversed, Moreno crossguide, and Riblet, were reviewed together with design methods and physical limitations. The paper was supplemented with slides, samples of couplers, and a demonstration. Prepared monographs on coupler design were distributed and a question-and-answer session was held.

News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

(Continued from page 58A)

Linear Scale Slide Rules

G. Groder, 2003 E. 12 St., Brooklyn 29, N. Y., has printed a booklet on Linear Scale Non-Logarithmic Slide Rules.

Written by Morris L. Groder, the book explains the difference between the linear and logarithmic rules, and the simple construction and application of the linear rule.

The book shows that addition, subtraction, multiplication and division can be accomplished on the same scales, and that addition or subtraction can be done while multiplying or dividing. For example, temperature conversion $T_c=0.556$ (T_f-32) a combination of multiplication and subtraction is solved in one setting of the linear slide rule.

Reciprocals, folded scales and logarithms can be obtained by drawing a straight line on the linear slide rule.

(Continued on page 99A)

SECTION MEETINGS

AKRON

"Ferroelectricity," by Dr. Hans Jaffe, The Brush Laboratories Company of Cleveland; January 21, 1954.

"Transistors," by G. B. Herzog, RCA Laboratories; February 18, 1954.

ALBUQUERQUE-LOS ALAMOS

"Our Expanding Technology," by J.W. McRae, Sandia Corporation; January 22, 1954.

"Errors in Microwave Impedance Measurement," by W. R. Hewlett, President, IRE; February 5, 1954.

ATLANTA

"A Modern Microwave System with Remote Supervisory Control of Pipeline Operation," by E. S. Lammers, Westinghouse Company; January 15, 1954.

BALTIMORE

"Color Television—Its Challenge to the Engineer," by D. G. Fink, Philco Corporation; January 13, 1954.

"Information Processing Machines," by Dr. S. N. Alexander, National Bureau of Standards; February 10, 1954.

BEAUMONT-PORT ARTHUR

"Industrial Vibrators," by C. R. Bowman, P. R. Mallory & Co., Inc.; January 28, 1954.

CEDAR RAPIDS

Installation of 1954 officers, Merrill S. Smith, Presiding; January 16, 1954.

CINCINNATI

"Heat Transfer from Electronic Equipment," by R. E. Pike, Wright Air Development Center; December 15, 1953.

"Communications Measurements," by N. B. Fowler, American Tel. and Tel. Company; January 19, 1954.

CLEVELAND

"Color Television," by Andrew Hammerschmidt, National Broadcasting Company; January 28, 1954.

CONNECTICUT VALLEY

"Recent Developments in Photomultipliers," by Dr. B. R. Linden, Allan B. Dumont Labs.; December 10, 1953.

"Magnetic Resonance," by Dr. K. K. Darrow, Bell Telephone Labs.; January 21, 1954.

"An Ultrasonic Machine Tool" (with demonttration) by Neil Clark, Jr. and J. Aloisio, Raysheon Manufacturing Co.; February 18, 1954.

DALLAS-FORT WORTH

"Transistors"—G. K. Teal, Presiding, W. A. Adcock: Materials; J. R. MacDonald: Fundamentals; J. W. Lacey: Manufacture; A. D. Evans: Circuits; J. W. Thornhill: Demonstrations. All of Texas Instruments, Inc.; January 25, 1954.

"The Present Status of Color Television," by A. G. Jensen, Bell Telephone Labs.; February 19, 1954.

DAYTON

"Aviation Electronics," by Capt. A. F. Van Dyck, USNR (Ret.) and Radio Corp. of America; "The Air Traffic Story," by N. L. Winters, Sperry Gyroscope Company; January 14, 1954.

"The Transistor From an Engineering Point of View," by D. E. Thomas, Bell Telephone Lab.; February 11, 1954.

DENVER

"The Physics of Music and Hearing," by W. E. Kock (by tapescript); Bell Telephone Labs.; January 22, 1954.

"Transistor Circuitry," by T. R. Finch; Bell Telephone Labs.; February 5, 1954.

(Continued on page 86A)

Heiland

Subminiature Galvanometer and Magnet Structure

for Heiland Recording Oscillographs

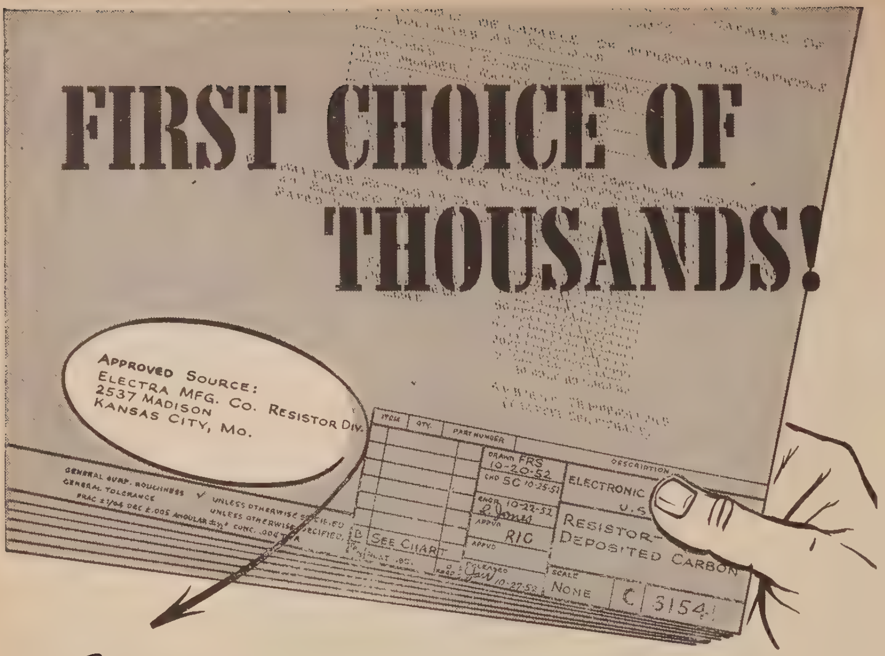
Heiland presents a new line of subminiature galvanometers and a new concept in the design of magnet structures.

Check these Quality Features

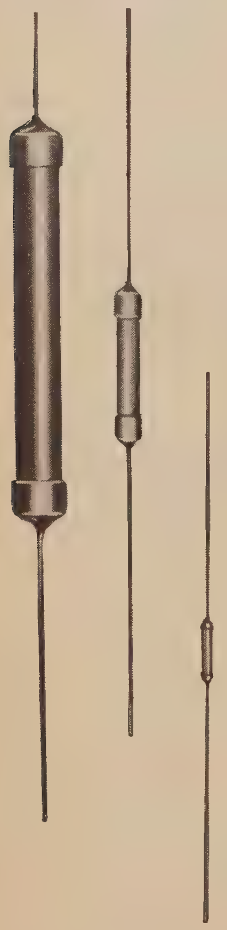
✓ Small-size, Compact
✓ High Sensitivity
✓ Extremely Stable
✓ Rugged Construction
✓ Low Drift
✓ Extended Frequency Range

Many additional features are incorporated to provide flexibility, reliability and ease of operation in all applications. Complete specifications will be released in the near future. Write or wire for complete details on Heiland Recording Oscillographs, Amplifiers and Bridge Balance Units.

Heiland Research Corporation
130 EAST FIFTH AVENUE · DENVER 9, COLORADO


FIRST CHOICE OF THOUSANDS!
APPROVED SOURCE:
ELECTRA MFG. CO. RESISTOR DIV.
2537 MADISON
KANSAS CITY, MO.
ELECTRONIC
RESISTOR–DEPOSITED CARBON
SEE CHART
NONE
C 3154

Electra Deposited Carbon Resistors



From Hearing Aids to Guided Missiles Electra Deposited Carbon Resistors have become "First Choice" on thousands of blueprints. Leading engineers have good reasons for this specified choice . . . Deposited carbon resistors because they are extremely stable, small in size, accurate to ± 1% but available also in other resistance tolerances and low in cost. *Electra* resistors are preferred because month after month, year after year, quality is always dependably high.

Purchasing and production people prefer Electra because of fast, dependable delivery—production schedules are met on time!

Electra Deposited Carbon Resistors are available in 8 sizes—$^1/_8$ watt to 2 watts, and in two types—coated as well as hermetically sealed. They are manufactured to specification MIL-R-10509 A.

Make your "First Choice" Electra Deposited Carbon Resistors!

Electra
carbon-coat
PRECISION RESISTORS

Write for complete information

Electra Manufacturing Co.
2537 Madison Avenue
KANSAS CITY 8, MISSOURI

SECTION MEETINGS

(*Continued from page 85A*)

DES MOINES-AMES

"Low Temperature Physics Research," by Dr. Sam Legvold, Iowa State College; January 27, 1954.

ELMIRA-CORNING

"Modern Glasses and Their Applications," by Dr. W. W. Shaver, Corning Glass Works; January 18, 1954.

EMPORIUM

"Registration of Professional Engineers in Pennsylvania," by J. T. West, Jr., Penna. Society of Professional Engineers; Color TV Demonstration, by James Allen, Sylvania Electric Products, Inc.; January 25, 1954.

EVANSVILLE-OWENSBORO

"Magnetic Amplifier Circuits," by A. E. Schmid, The Magnavox Company; January 13, 1954.

"Instrumentation in Seismology," by Dr. Florence Robertson, St. Louis University; February 10, 1954.

FORT WAYNE

"The Air Defense of the United States," by Dr. H. H. Porter, Johns Hopkins University; February 4, 1954.

HOUSTON

"Colored Television," by W. J. Morlock, General Electric Co.; January 26, 1954.

"Aspects of Vehicular Communication," by W. A. Shipman, Columbia Gas System; Film, "Onan on Safari"; February 16, 1954.

HUNTSVILLE

Scientific Show: "Energy in Action." Speakers: Robert Dollison and Robert Best, Westinghouse Reporters; January 15, 1954.

INYOKERN

"A Timing and Firing System for the Range Instrumentation of Guided Missiles at the Air Force Missle Test Center," by Mr. Bonney, Electronic Engineering Company of California; February 8, 1954.

LITTLE ROCK

"Magnetic Amplifiers and Their Applications to Temperature Control," by R. I. Van Nice, Westinghouse Electric Corp.; February 9, 1954.

LONDON

"The Microtron Electron Accelerator and Photo Multiplier Detector," by Dr. Erick Brennan, University of Western Ontario; January 25, 1954.

"Training Systems Used in Radio Physics Four Year Course at U.W.O.," by Professors Dearle and Tull, University of Western Ontario; February 8, 1954.

LOS ANGELES

"Magnetic Television Tape Recording," by J. T. Mullin, Bing Crosby Enterprises; January 5, 1954.

"A Look at Engineering Education in Great Britain," by Leslie Cromwell, Faculty, Los Angeles State College; "Some Characteristics of Military Research and Development," by Dean E. Wooldridge, Ramo-Wooldridge Corp.; February 2, 1954.

LOUISVILLE

"Recent Advances in Transistor Design and Applications," by T. R. Finch, Bell Telephone Labs.; January 28, 1954.

MIAMI

"The Development and Growth of the Magnetic Recorder Industry," by J. Herbert Orr; Orradio Industries, Inc.; January 29, 1954.

(*Continued on page 88A*)

SPECIFIC TUBE DESIGN SERVICE · SPECIFIC TUBE APPLICATION SERVICE · LOCAL LABORATORY-TESTING SERVICE · COAST-TO-COAST WAREHOUSING SERVICE · NON-STOP ORDER AND DELIVERY SERVICE

Now INSTALL G-E 5-STAR TUBES ACROSS THE BOARD IN AIRCRAFT AND MOBILE RECEIVERS!

With the new GL-6265, put high reliability in every socket! You can fill half your design needs with this one type!

G-E DESIGN SERVICE brings you the versatile new GL-6265—which meets 45% to 65% of your tube needs, replacing Type 6BH6. Electrical differences from the 6BH6 are minor. There are only a very few cases in which any circuit adjustment will be necessary.

RELIABLE TUBES THROUGHOUT! No more breaks in your chain of high-reliability tubes! Now *all* your receiver sockets can have 5-Star types—every tube designed, built, and tested for maximum dependability. You can build and sell communications equipment that sets new standards of unfailing performance in the air, on the ground, wherever complete dependability is a "must".

BE FIRST TO OFFER receivers with General Electric 5-Star Tubes handling every stage from signal input to audio output! Get all the facts about the new GL-6265! Wire or write today for Bulletin ETD-892 to *Tube Department, General Electric Company, Schenectady 5, New York.*

NEW

GL-6265

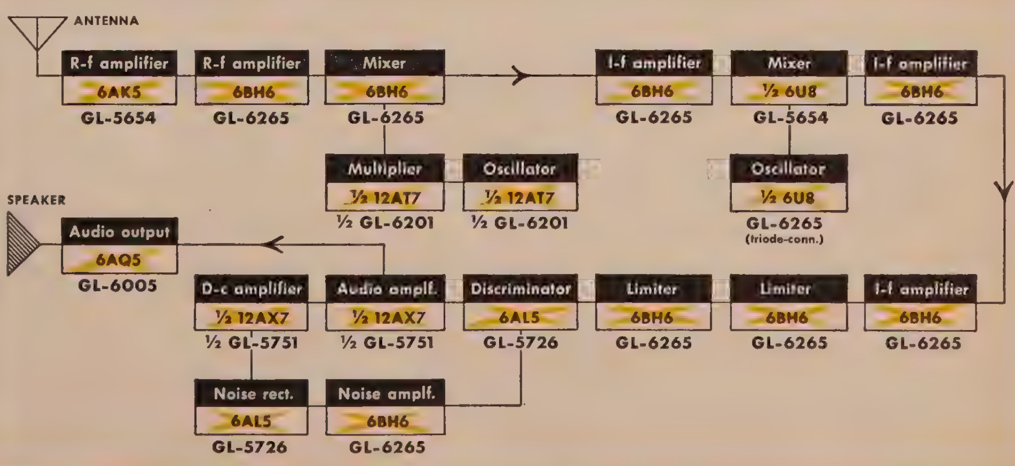
★★★★★

Sharp-cutoff pentode, for r-f or i-f amplification.

REPLACES 6BH6

100% HIGH-RELIABILITY TUBES!

Every socket in this 152-mc-to-174-mc mobile receiver can be filled with a G-E 5-Star Tube, giving your equipment day-in, day-out dependable performance with lower maintenance, fewer tube replacements. 9 out of the 16 G-E 5-Star Tubes in this circuit (56%) are GL-6265's!


ANTENNA
R-f amplifier 6AK5 GL-5654
R-f amplifier 6BH6 GL-6265
Mixer 6BH6 GL-6265
I-f amplifier 6BH6 GL-6265
Mixer ½ 6U8 GL-5654
I-f amplifier 6BH6 GL-6265
Multiplier ½ 12AT7 ½ GL-6201
Oscillator ½ 12AT7 ½ GL-6201
Oscillator ½ 6U8 GL-6265 (triode-conn.)
SPEAKER
Audio output 6AQ5 GL-6005
D-c amplifier ½ 12AX7 ½ GL-5751
Audio ampl. ½ 12AX7 ½ GL-5751
Discriminator 6AL5 GL-5726
Limiter 6BH6 GL-6265
Limiter 6BH6 GL-6265
I-f amplifier 6BH6 GL-6265
Noise rect. 6AL5 GL-5726
Noise ampl. 6BH6 GL-6265

GENERAL ELECTRIC

162-1B6

NEW

AMPHENOL Components

stamped with the quality trademark—

AMPHENOL

miniature

165 Series

The new AMPHENOL 165 series miniature AN-type connectors average about ⅓ the weight of standard ANs but retain the many features initiated by AMPHENOL in the larger connectors. The 165 series are the latest AMPHENOL contribution to the continuing program of miniaturization of components for instrumentation.

Qwik

microphone connectors

AMPHENOL QWIK Microphone Connectors are the newest, the most efficient and certainly the most attractive connectors ever offered for audio applications. They are available in 3 or 4 contacts and feature tough construction coupled with fine materials. Contacts are plated with *gold* over silver finished bronze.

aljak cable

ALJAK coaxial cable has been designed by AMPHENOL to permit a wider scope to cable applications in critical electronic equipment. Waterproof and semi-flexible, ALJAK is made with a tough aluminum jacket over extruded Teflon or polyethylene dielectric. The cable has very low attenuation as well as a smaller o.d. than equivalent RG type cables.

For further information about all of these AMPHENOL *component write and request the special literature which has been prepared.*

AMERICAN PHENOLIC CORPORATION

chicago 50, AMPHENOL *illinois*

SECTION MEETINGS

(Continued from page 86A)

MONTREAL

"A Popular Approach to the Problem of Quality Acoustics in Radio Broadcasting," by R. E. Penton, Can. Broadcasting Corp.; January 25, 1954.

NEW YORK

"Civil Defense Communications," by R. S. Healy, N. Y. State Civil Defense Commission; January 6, 1954.

"FM Broadcast Multiplex Techniques and Applications," by W. S. Halstead, Multiplex Development Corp., and United, Inc.; February 3, 1954.

OMAHA-LINCOLN

"Sylvania's Rocket Planar Grid Tube," by R. A. Vashon, Sales Engineer; February 1, 1954.

OTTAWA

"Successful Reception of Radio-Teletype Signals and Reduction of Distortion Noise & Interference," by R. Elliott; "Automatic Machines Using Printed Wiring Circuits," by L. L. Marzec; "Transistors," by F. O. Bogstad; and "Mutual Conductance of Pentodes," by G. R. Fanjoy, all students; January 19, 1954.

PHILADELPHIA

"Communications and the Future," by J. W. McRae, Sandia Corporation; February 3, 1954.

"Background of Color TV," by D. G. Fink, Philco Corp.; "Color Theory, Colorimetry," by F. J. Bingley, Philco Corp.; February 11, 1954.

"Compatible Color TV," by J. W. Wentworth, RCA; February 18, 1954.

PHOENIX

"Electronic Analog Computers Using Feedback Amplifiers," by R. V. Baum, Goodyear Aircraft Corp.; December 18, 1954.

PITTSBURGH

"Materials and Methods for Modern Electronics," by R. E. Stark, Philip Kattan and Joseph Stern, Stupakoff Ceramic and Mfg. Co.; February 8, 1954.

PORTLAND

"I.B.M. Model 701 High-Speed Electronic Computer," by S. L. Lida, I.B.M.; January 14, 1954.

Film, "Project Tinkertoy"—discussed by George Ellison; January 18, 1954.

PRINCETON

"A Radio Engineer Visits Europe," by E. W. Herold, RCA Labs.; January 14, 1954.

"Compatible Color Television," by Dr. G. H. Brown, RCA Labs.; February 4, 1954.

"Some Electronic Methods for the Observation of Life Processes," by Dr. Britton Chance, E. R. Johnson Foundation; February 11, 1954.

ROCHESTER

"A Progress Report on Atomic Power Development," by R. G. Lorraine, General Electric Company; February 4, 1954.

ROME-UTICA

"The International Electrotechnical Commission," by E. L. Seaman, USN Bureau of Ships; "Two Brief Looks at London by an American Electronic Engineer," by H. F. Mayer, General Electric Co.; February 2, 1954.

ST. LOUIS

Microwave Demonstration by G. M. Cummings and Irwin Mattick, Southwestern Bell Telephone Company; December 10, 1954.

"Bilateral Feed-back Stability," by Prof. P. M. Honell, Washington University; January 28, 1954.

(Continued on page 90A)

by every test
ATR is BEST!
ATR
ATR VIBRATOR TYPE 524
ATR REPLACEMENT VIBRATOR TYPE 524

ATR AUTO RADIO

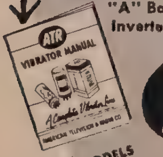
VIBRATORS

Have Ceramic Stack Spacers

A COMPLETE LINE OF VIBRATORS

Designed for Use in Standard Vibrator-Operated Auto Radio Receivers. Built with Precision Construction, featuring Ceramic Stack Spacers for Longer Lasting Life. Backed by more than 22 years of experience in Vibrator Design, Development, and Manufacturing.

Free



"A" Battery Eliminators, DC-AC Inverters, Auto Radio Vibrators

ATR

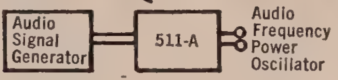
√ NEW MODELS √ NEW DESIGNS √ NEW LITERATURE

See your jobber or write factory

AMERICAN TELEVISION & RADIO CO.
Quality Products Since 1931
SAINT PAUL 1, MINNESOTA—U. S. A.

TIEnography of INSTRUMENTS

TYPE 511-A POWER AMPLIFIER



- **PHASE SHIFT COMPENSATION**
- **NEGLIGIBLE DISTORTION**
- **HIGH VOLTAGE OUTPUT LEVEL**

. . . a general purpose laboratory power amplifier featuring low distortion, low noise and excellent phase characteristics throughout the frequency range from 50 cps. to 50 kc. A choice of four outputs available to match various loads (5, 25, 200 or 1200 ohms). The 511A Power Amplifier is especially useful as a test driving source for tachometers, synchros, small motors, choppers, electro-mechanical devices and, with an audio frequency signal generator, as a power oscillator.

At rated frequencies and gain settings the overall phase shift is small. A special feature is the phase compensation circuit which permits the overall phase shift to be maintained at a constant value with varying gain. Harmonic distortion and intermodulation distortion are low. Output voltage up to 120 volts into a 1200 ohm load. Operates into loads varying from pure resistance to pure reactance.

The flexible system of phase shift control makes the 511-A Power Amplifier ideal for use in conjunction with phase measuring equipment as a power source in the investigation of phase characteristics of transmission lines, transformers, filters or equalizing networks, saturable reactors, magnetic amplifiers, and in acoustical measurements.

SPECIFICATIONS:

Output Characteristics and Gain (for 0.5% max. allowable harmonic distortion):

OUTPUT SELECTOR (Front Panel Control)	E_{out} Max.	Voltage Gain	Optimum Load	P_{out} Max.
Position 1	8 volts	1.4	5 ohms	12.8 W
Position 2	18 volts	2.8	25 ohms	13.0 W
Position 3	55 volts	8.0	200 ohms	15.1 W
Position 4	120 volts	21.0	1200 ohms	12.0 W

INPUT IMPEDANCE: 100 K ohms shunted by approximately 10 uuf.

FREQUENCY RESPONSE: At 10 watts or less output, essentially flat from 50 cps to 30 kc, down 0.5 db at 50 kc. At 10 to 16 watts, essentially flat from 50 cps to 30 kc, down 1.0 db at 50 kc.

HARMONIC DISTORTION: At 10 watts or less output, less than 0.5% total harmonic distortion (rms). At 10 to 16 watts output, less than 1.0% total harmonic distortion (rms).

PHASE SHIFT: 1.0° ±1.5° from 50 cps to 10 kc.

Phase shift may be compensated at any single frequency to remain constant for all gain settings. Phase shift may also be made zero for a single frequency and a single gain setting.

INTERMODULATION DISTORTION (rms): Less than 0.5% from 50 cps to 15 kc for difference frequency of 150 cycles.

OUTPUT REGULATION: ±5% of rated output voltage from optimum load to open circuit on all ranges.

HUM AND NOISE: Less than 15 mv. with input shorted.

TECHNOLOGY INSTRUMENT CORP.

535 MAIN ST., ACTON, MASS., ACton 3-7711

NEW
lower priced FOCOMAG
USES
SINGLE
FERRITE MAGNET

Another HEPPNER First

- Lower priced, compact. Cuts receiver costs. Uses only ONE ferrite magnet (an exclusive feature).
- Superior focusing - more uniform field. The sintered ferrite is extremely uniform throughout. Focuses all tubes up to 27".
- Completely shielded. No harmful external field.
- Extended focus range has very fine adjustment to exact focus.
- Built-in centering device.
- Flexible nylon adjusting shaft eliminates breakage.
- Picture positioning lever. You specify mounting arrangement.

Lower your set costs with this NEW FOCOMAG. Write today for further information.

HEPPNER
MANUFACTURING COMPANY
Round Lake, Illinois (50 Miles Northwest of Chicago)
Phone: 6-2161
SPECIALISTS IN ELECTRO-MAGNETIC DEVICES

Representatives: **John J. Kopple**
60 E. 42nd St., New York 17, N. Y.

James C. Muggleworth
506 Richey Ave., W. Collingswood, N. J.

Ralph Haffey
R. R. 1, U. S. 27, Coldwater Rd.,
Ft. Wayne 8, Indiana

Irv. M. Cochrane Co.
408 So. Alvarado St., Los Angeles, Calif.

SECTION MEETINGS

(Continued from page 88A)

San Diego

"A Modulator Technique for Producing Short Pulses in High Powered Magnetrons," by T. J. Parker, Navy Electronics Lab.; February 2, 1954.

Schenectady

"Current Trends in Electrical Engineering," by Prof. H. W. Bibber, Union College; February 8, 1954.

Seattle

"The VAW Meter," and "The Precision Regulated Power Supply," by J. M. Fluke, John Fluke Mfg. Co., Inc.; December 16, 1954.

"The L-C Meter," by C. H. Moulton, Tektronix, Inc.; January 15, 1954.

Toronto

"VHF and UHF Measurement Techniques," by W. A. Cumming, National Research Council; November 16, 1954.

"Production Engineering Aspects of a Lightweight Military Equipment," by A. L. Rosenthal, Canadian Radio Mfg. Corp.; December 7, 1954.

"Recent Developments in Color TV," by W. B. Whalley, Polytechnic Research and Development Company; January 11, 1954.

"The Buffalo, Toronto, Montreal Microwave Radio System," by A. J. Groleau, Bell Telephone Company; January 25, 1954.

Tulsa

"Information Theory," by Dr. R. G. Piety, Phillips Petroleum Company; January 21, 1954.

Twin Cities

"An Automatic Telephone Answering Device," by A. D. Knowlton, Bell Telephone Labs.; February 1, 1954.

"Advances in Communication Engineering Thru Microwaves," by N. B. Tharp, Westinghouse Electric Company; February 18, 1954.

Vancouver

Field Trip to TV Station CBUT; January 18, 1954.

Washington, D. C.

"Surface Barrier Transistors: Construction and Application," by W. E. Bradley, W. H. Forster and J. B. Angel, Philco Corp.; January 11, 1954.

"A Review of the ARINC Military Reliable Tube Project," by C. R. Knight, Aeronautical Radio, Inc.; February 8, 1954.

Winnipeg

"Radio-Astronomy," by Dr. B. W. Currie, University of Saskatchewan; January 13, 1954.

"The TD—2 Microwave Link," by A. J. Groleau, Bell Telephone Co.; February 17, 1954.

SUBSECTIONS

Lancaster

"Electrical Welding of Industrial and Electronic Glassware," by E. M. Guyer, Corning Glass; February 9, 1954.

Mid-Hudson

"Practical Applications of Infrared Detecting Systems," by William Dergano, Servo Corporation of America; December 15, 1954.

"Color Television," by R. J. Mahler, Columbia Broadcasting System, January 25, 1954.

Monmouth

"The Backward Wave Oscillator," by J. F. Hull, SCEL; January 27, 1954.

Northern New Jersey

"Elementary Electronic Circuit Analysis From an Advanced Standpoint," by Prof. S. J. Mason,

(Continued on page 92A)

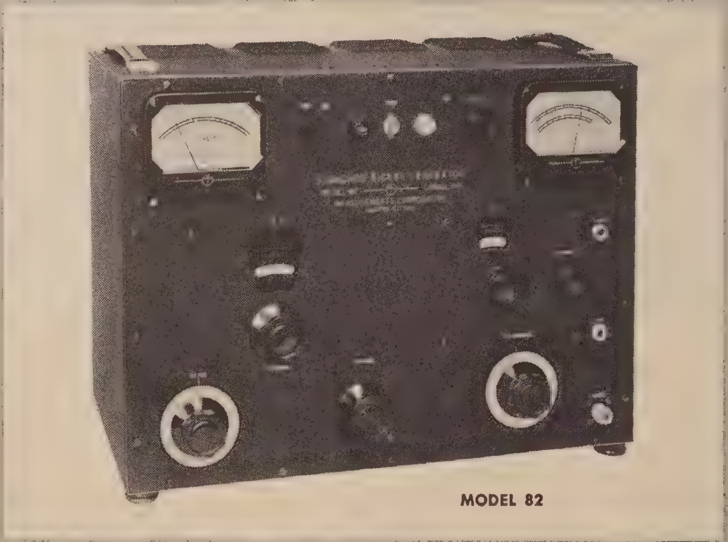
AT THE MOST CRITICAL SECONDS
I.
II.
III.
IV.

wilcox
EQUIPMENT
NEVER FAILS YOU

Whether it's on the ground or airborne, for communications or navigation, Wilcox Equipment, built with an extra margin of reliability, never fails you when you need it most. If you are planning an investment in this type of equipment . . . investigate dependable Wilcox Equipment *first.*

wilcox
ELECTRIC COMPANY, INC.
Fourteenth & Chestnut
Kansas City 1, Missouri, U.S.A.

This ONE instrument checks RF, IF, and AF performance of receivers


MODEL 82

MEASUREMENTS'

Standard Signal Generator

Frequency Range: 20 cycles-50 mc.

The Model 82 Standard Signal Generator provides extremely wide frequency coverage. It comprises a low-frequency oscillator covering the range from 20 cycles to 200 kc., and a high-frequency oscillator in the range from 80 kc. to 50 mc.

It is designed for audio and radio frequency measurements of AM, FM and television receivers; for testing and checking the frequency response of audio systems; as a driving source for AF and RF bridges; for testing video and wideband amplifiers.

FEATURES:

- Continuous frequency coverage from 20 cycles to 50 mc.
- Direct-reading individually calibrated dials.
- Low harmonic content.
- Accurate, metered output.
- Mutual inductance type attenuator for high frequency oscillator.
- Stray field and leakage negligible.
- Completely self-contained.

SPECIFICATIONS:

FREQUENCY RANGE: 20 cps to 200 kc. in four ranges. 80 kc. to 50 mc. in seven ranges, plus one blank range.

FREQUENCY CALIBRATION: Each range individually calibrated. 20 cps to 200 kc. accurate to ±5%. 80 kc. to 50 mc. accurate to ±1%.

OUTPUT VOLTAGE AND IMPEDANCE: 0-50 v. across 7500 ohms from 20 cycles to 200 kc.; Output voltage and impedance in this range can be reduced by external attenuator. 0.1 µv. to 1 v. across 50 ohms over most of the range from 80 kc. to 50 mc.

MODULATION: Continuously variable from 0-50% from 20 cycles to 20 kc. from internal variable oscillator or external source.

HARMONIC OUTPUT: Less than 1% from 20 cycles to 20 kc.; 3% or less from 20 kc. to 50 mc.

LEAKAGE AND STRAY FIELD: Less than 1 µv. from 80 kc. to 50 mc.

POWER SUPPLY: 117 v., 50-60 cycles. 75 watts.

Laboratory Standards

MEASUREMENTS CORPORATION
BOONTON · NEW JERSEY

SECTION MEETINGS

(Continued from page 90A)

Mass. Institute of Technology; December 9, 1954.

"Focusing Sound Waves with Microwave Lenses," by F. K. Harvey, Bell Telephone Labs.; January 13, 1954.

ORANGE BELT

"Color Television Tubes and Circuits," by Dr. E. L. Michaels, Packard Bell Television; February 10, 1954.

PALO ALTO

"Survey of Recent Advances in the Communication Theory of Reception," by David Middleton, Faculty, Harvard University; January 20, 1954.

TUCSON

Election of officers and general meeting; January 29, 1954.

USAFIT

"Transistors," by Dr. W. L. Lehmann, USAFIT; January 22, 1954.

STUDENT BRANCH MEETINGS

ALABAMA POLYTECHNIC INSTITUTE, IRE BRANCH

"Transistors" by Harold E. O'Kelley, Faculty, Alabama Polytechnic Institute; January 25, 1954.

CASE INSTITUTE OF TECHNOLOGY, IRE BRANCH

"Ultrasonics" by Dr. O. Mattiat, Brush Development, Cleveland, Ohio; November 10, 1953.

"Cathodic Protection," by A. R. Corlett, Harco Corp., Cleveland, Ohio; November 24, 1953.

Business Meeting; February 16, 1954.

UNIVERSITY OF DAYTON, IRE-AIEE BRANCH

"Meters of Both AC and DC Types," by Paul Blaeser, Chairman; November 3, 1953.

"Power Factor Measurement," by William F. Herndon, Secretary; November 10, 1953.

Business Meeting; November 17, 1953.

"The Operation of the Multi-Vibrator," by Jim Braun, Student; November 24, 1953.

"Lightning," by Don Brennan, Student; December 1, 1953.

Film, "Elements of Electricity"; December 15, 1953.

UNIVERSITY OF FLORIDA, IRE-AIEE BRANCH

"Logic and Switching," by Dr. W. H. Chen, Faculty Univ. of Florida and Business Meeting; November 24.

"Hypnosis by Electronics," by M. J. Wiggins, Faculty, Univ. of Florida; December 8, 1953.

"Accurate Temperature Control of Induction Heating Units," by George F. Perdue and James E. Moreland, Student Assistants, working on an Air Force Project; January 12, 1954.

STATE UNIVERSITY OF IOWA, IRE BRANCH

"Nature and Use of Digital Computers," by Gayland Pohren, Senior Student, S.U.I.; Election of Officers, January 20, 1954.

JOHNS HOPKINS UNIVERSITY, IRE-AIEE BRANCH

Business Meeting; January 6, 1954.

"The Westinghouse Student Training Program," by H. E. Robertson, Westinghouse; January 13, 1954.

(Continued on page 94A)

From "The House of Resistors" comes...

Precise

CONTROL

★ Series 52 potentiometers are available in 1 to 18 section tandems. Single shaft, simultaneously controlled.

★ Prong terminals engage with corresponding jacks for plug-in circuitry.

★ Overall tolerances to plus/minus 0.5% where resolution permits. Voltage ratio accuracy of 0.005.

★ Molded low-loss mica-filled phenolic casings. Corrosion-resistant materials and plating throughout.

★ Life of over 1,000,000 cycles. These controls exceed applicable JAN-R-19 specifications.

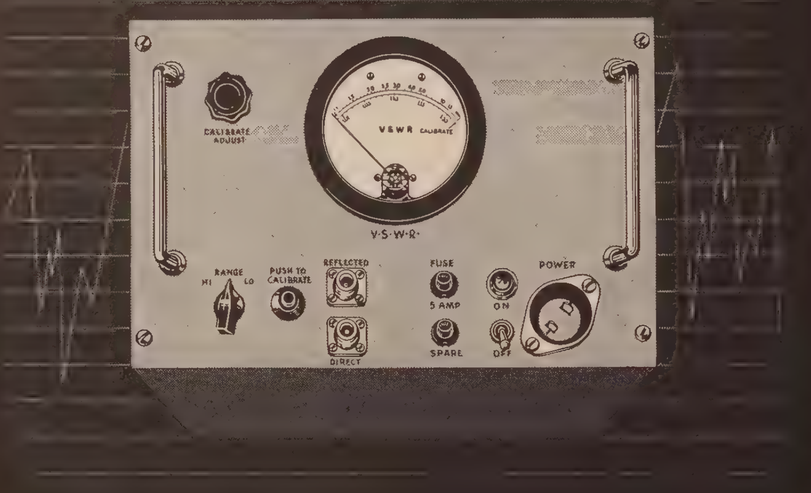
IT'S EASY TO DO BUSINESS WITH CLAROSTAT...

Representatives in all principal cities. Wire Western Union — we have a direct wire. Telephone (Dover 979) we have added trunk lines to render service. Teletype—our TWX number is Dover 275-U.

STAND PAT WITH®
CLAROSTAT

CONTROLS AND RESISTORS
CLAROSTAT MFG. CO., INC., DOVER, NEW HAMPSHIRE
In Canada: Canadian Marconi Co., Ltd., Toronto, Ontario

WHAT'S New IN SCOPE
...for RADAR?



CUBIC'S New VSWR INSTRUMENTATION SYSTEM
for continuous . . .
automatic . . .
measurement of VSWR

The New Model 620 is CUBIC'S contribution to higher efficiency and higher economy in that new RADAR design you may be planning. Designed for field and production use—where frequent VSWR measurements of radar, and other amplitude modulated microwaves are required, it has certain important features entirely new:

- *Measurement of VSWR is continuous and automatic over two calibrated ranges, covering ratios 1.02 to 1.2, and 1.2 to 00.*
- *Can be used with CUBIC'S matched directional coupler—permanently or temporarily installed in waveguide run.*
- *Available too as JAN AN/UPM-12 Military version.*
- *And available in Model 621, for VSWR measurements at signal generator levels.*
- *For x-band only, at present. RF components will be ready shortly for operation on S thru Ku band.*

New designs make new demands. CUBIC engineers are constantly conducting research to develop new products to enable those new Electronic designs—still on the drafting boards, to become reality. In this connection, our Engineering and service departments are always at your disposal on any Electronic problem.

Write for latest edition of our catalog of microwave instruments

CUBIC CORPORATION
ELECTRONIC EQUIPMENT
RESEARCH...DEVELOPMENT
SAN DIEGO 6 CALIFORNIA

STUDENT BRANCH MEETINGS

(Continued from page 92A)

University of Kansas, IRE-AIEE Branch

"Instrumentation in Engineering," by C. E. Alberts, Bailey Instrument Co.; February 11, 1954.

Lehigh University, IRE Branch

"Research at Westinghouse," by Dr. C. Hestrom, Westinghouse; January 21, 1954.

University of Maine, IRE Branch

"Automatic Pilot—The Gyro Pilot," by Paul E. Cyr, Student member IRE; February 11, 1954.

Marquette University, IRE-AIEE Branch

General Meeting; December 10, 1953.

Election of Officers and General Meeting; January 6, 1954.

Business Meeting; January 14, 1954.

University of Massachusetts,
IRE-AIEE Branch

"The Operation and Construction Difficulties of Fractional Horsepower Motors," by L. C. Packer, Westinghouse Elec. Corp.; November 18, 1953.

"Various Means of Generating a High Voltage Spark in Different Types of Ignition Systems," by Mr. Kongstaff, American Bosch Company; December 17, 1953.

"Delay Lines" by A. Sable, H. Sickles Corp., Massachusetts; January 7, 1954.

Michigan College of Mining & Technology,
IRE-AIEE Branch

General Meeting; January 26, 1954.

Michigan State College, IRE-AIEE Branch

"The Application of The Electron Microscope," by Dr. H. H. Bendler, Faculty, M.S.C.; January 27, 1954.

"Photogrammetry Techniques," by Ted Abrams, Abrams Instrument Co. and General Meeting; February 10.

University of Nebraska, IRE-AIEE Branch

General Meeting; February 10, 1954.

North Carolina State College, IRE Branch

Election of Officers and General Meeting; February 8, 1954.

North Dakota Agricultural College,
IRE-AIEE Branch

Film, "Coaxial Cable," and "Microwave Relays"; November 18, 1953.

General Meeting; December 2, 1953.

University of North Dakota,
IRE-AIEE Branch

Election of Officers; January 19, 1954.

General Meeting; February 18, 1954.

Northeastern University, IRE-AIEE Branch

"Some Technical Aspects of Electrocardiography," by Dr. Arthur Miller, Sanborn Co.; December 29, 1953.

"Recent Developments in the Power Field," by Mr. Ribb, General Electric Co.; January 7, 1954.

Field Trip—through the fire alarm center in Boston; January 14, 1954.

Films, "Radar Anti-jamming Devices," and "Cathode Ray Tube"; January 21, 1954.

Ohio State University, IRE-AIEE Branch

"Engineering Ethics and Attitudes," by Mr. Corcoran, Central Ohio Personnel Assoc., Mr. Paul Mazuzan, Industrial Relations Assoc, Mr. McMaster, Supervisor at Battelle Memorial Institute; February 9, 1954.

(Continued on page 96A)

Built into KAHLE
automatic machinery
is knowledge
of every
phase
of electronic
tube
production...

Kahle's machines are engineered to manufacture electronic tubes so that the burden of "knowing how" to make the product falls upon the machinery itself instead of the manufacturer. Forty-six years of intimate contact with the design and construction of custom machinery together with a long history of pioneering successes in electronics and allied industries, produce "know-how". Kahle executives have vast experience in the actual manufacturing of the end products which such machinery produces. This cumulative knowledge is built into the machinery to solve bottlenecks and gives a smooth uninterrupted flow of the finished products.

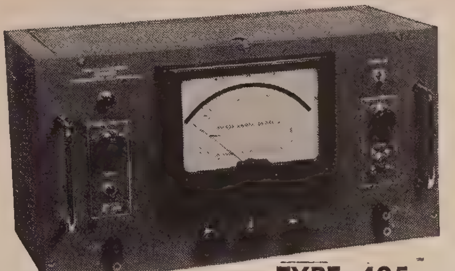
"Built-in know how" is what makes Kahle's name the password in the electronics and glass industries where production difficulties can be overcome with custom machinery. Call on Kahle and learn how you can benefit from the company which enjoys the respect of the industry's leaders.

Kahle
ENGINEERING COMPANY
1312 SEVENTH STREET
NORTH BERGEN, N. J.

©NTI

NEW... **PHASE METER**

0.5° RELATIVE ACCURACY



TYPE 405

0.3 VOLT SENSITIVITY
8 CPS TO 100 KC

- DIRECT MEASUREMENT OF PHASE FROM BELOW 1° TO 360°.
- EQUAL ACCURACY FOR SYMMETRICAL WAVEFORMS OF ANY SHAPE.
- NO AMPLITUDE ADJUSTMENT.
- BUILT-IN AUDIO OSCILLATOR INCLUDED.

Type 405 Phase Meter is a simple and convenient device for studying phase relationship between two signals. Very suitable for plotting phase-frequency curves on a cathode ray oscilloscope or a mechanical recorder. Ideal for production work.

SPECIFICATIONS

FREQUENCY RESPONSE: 8 cps to 100 kc. Both the upper and lower limit can be extended with increasing amplitude of both input signals.

PHASE RANGE: There are three ranges with sensitivity of 0-36, 0-90, 0-180 degrees. A panel switch is provided for inserting 180 degrees phase shift in order that the above three ranges may be converted to 180-216, 180-270, and 180-360 degrees.

ACCURACY: The maximum error is less than ±3% or ±2° at any range.

INPUT VOLTAGE: 0.3 volt to 70 volts from 8 cps to 100 kc. The lower limit increases exponentially for signals above 100 kc. and below 8 cps.

INPUT IMPEDANCE: 1 megohm shunted with 20 uuf on both input channels.

INPUT POWER: 115 volts or 230 volts rms, ±10%, 50-60 cycles, 60 watts.

COMPARISON ACCURACY: 0.5° or better.

PRICE $485.00

WRITE FOR DATA!

ADVANCE ELECTRONICS CO.

451 HIGHLAND AVE. PASSAIC, N.J.

IF IT'S NEW . . . IF IT'S NEWS . . . IT'S FROM ELCO

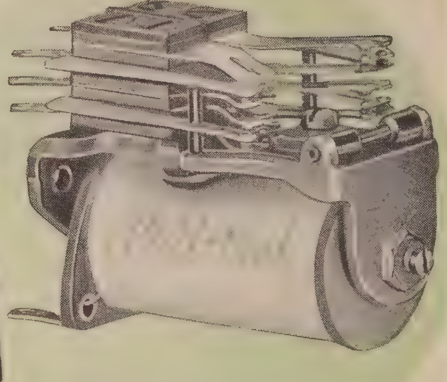
ELCO
VARICON
CONNECTOR KIT
ASSEMBLE YOUR OWN CONNECTORS
when and how you need them

Now at last, it is possible for you to assemble your own connectors when you want them, the way you want them, with Elco's Varicon Connector Kit. Yes, from America's quality manufacturer of sockets, shields and connectors comes this sensational Kit containing all parts needed for almost any type of miniature connector, with any number of circuits. Variations in arrangement of contacts at time of assembly makes possible the use of more than one connector, with the same number of contacts, but with different polarity. As for Varicons, they're the famous miniature connectors with identical male and female components; high current and voltage rating; low resistance, low capacitance. Your finished connectors will be precision connectors of high quality, appearance, practicability and versatility. Kits are available in general purpose phenolic black or in colors; low-loss mica; or alkyd. Sold exclusively through jobbers. Moderate price. Order your Varicon Connector Kit at once.

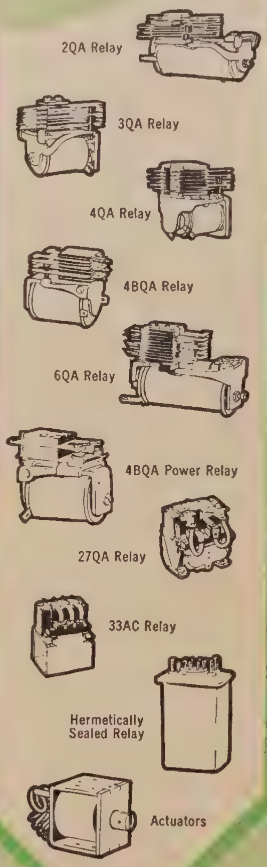
For Name of Nearest Jobber, Write or Phone ELCO Corporation
190 W. Glenwood Ave., Phila. 40, Pa.; GArfield 6-6620

When Contact Reliability is most important...

the NEW 8QA MULTI-CONTACT D.C. Phil-trol RELAY



...another addition to the many types of Phil-trol Relays...

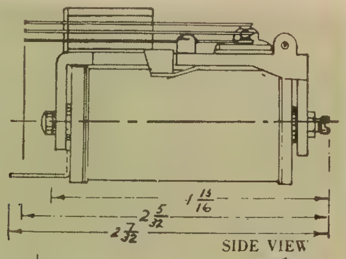


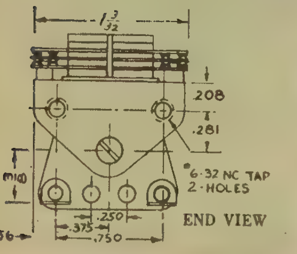
Rugged dependability plus high sensitivity have made this new Phil-trol relay an immediate favorite with engineers and designers. Its compactness and adaptability to a wide range of applications and uses provide new answers to the many complex problems confronting electronic and control engineers.

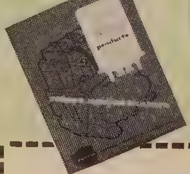
Unusual features of the new 8QA relay include immediate response; fast closing and opening; contact springs with twin contacts; heavy duty, long-life bronze bearings; light weight.

Like all standard Phil-trol relays, the 8QA is available in a wide range of modifications. Coils may be single or double wound, and equipped with copper slugs or sleeves for slow release or for slow operation.

In all probability, there is a standard Phil-trol relay, or variation, to meet your specific need. Phil-trol engineering experience and design facilities are available to help you solve any new application problem.







Phil-trol

IS THE REGISTERED TRADE MARK OF
PHILLIPS CONTROL CORP.
JOLIET, ILLINOIS
A THOR CORPORATION SUBSIDIARY
OFFICES IN ALL PRINCIPAL CITIES

PHILLIPS CONTROL CORP.,
Dept. PI, Joliet, Illinois

Please send me a free copy of the new Phil-Trol Relay and Actuator Catalog. Also, please arrange to have a Phil-Trol Sales Engineer call on me.

Name__________

Company__________

Street__________

City__________ Zone_____ State________

STUDENT BRANCH MEETINGS

(Continued from page 94A)

OKLAHOMA AGRICULTURAL & MECHANICAL COLLEGE, IRE-AIEE BRANCH

"Color Television," by E. A. Shore, General Electric Co.; February 1, 1954.

PRINCETON UNIVERSITY, IRE-AIEE BRANCH

"Analog Computer," by Prof. Insley Pyne, Faculty, Princeton Univ.; November 13, 1953.

"Magnetic Amplifier," by Prof. Walter C. Johnson, Faculty, Princeton Univ.; December 9, 1954.

UNIVERSITY OF SOUTHERN CALIFORNIA, IRE-AIEE BRANCH

"Purposes of the IRE and the Founders Societies," by G. W. Reynolds, IRE Advisor, Lewis, R. C. (Aiee Advisor) both Professors at U.S.C. and General Meeting; February 17, 1954.

STANFORD UNIVERSITY, IRE-AIEE BRANCH

"The Electrical Digital Computer," by L. D. Stevens, I.B.M.; February 4, 1954.

TEXAS TECHNOLOGICAL COLLEGE, IRE-AIEE BRANCH

"High Fidelity Sound Reproduction," by Tom B. Stenis, Faculty, Texas Tech.; February 15, 1954.

UNIVERSITY OF TORONTO, IRE-AIEE BRANCH

"Graduate Studies," by Prof. G. F. Tracy, Faculty, Univ. of Toronto; January 15, 1954.

"Long Range Planning," by R. W. Ray, Bell Telephone Co. of Canada; January 22, 1954.

"Program Network," by Wm. Cumberland, Canadian National Telegraphs; January 29, 1954.

"Economics of the Telephone Business," by Mr. Gardner, Bell Telephone Co. of Canada; February 5, 1954.

"Miniaturization of Telephone Equipment," by R. A. Cline, Bell Telephone Co. of Canada; February 12, 1954.

UTAH STATE AGRICULTURAL COLLEGE, IRE BRANCH

"R. F. Measurements," by Larry S. Cole (Professor of Elec. Engrg. U.S.A.C.); January 25, 1954.

"Future Success Story," by Reynold K. Watkins, Faculty, U.S.A.C.; February 11, 1954.

VIRGINIA POLYTECHNIC INSTITUTE, IRE-AIEE BRANCH

Film, "Underwater Giant"; February 9, 1954.

WAYNE UNIVERSITY, IRE-AIEE BRANCH

General Meeting; January 15, 1954.

UNIVERSITY OF WISCONSIN, IRE-AIEE BRANCH

Election of Officers and General Meeting; January 12, 1954.

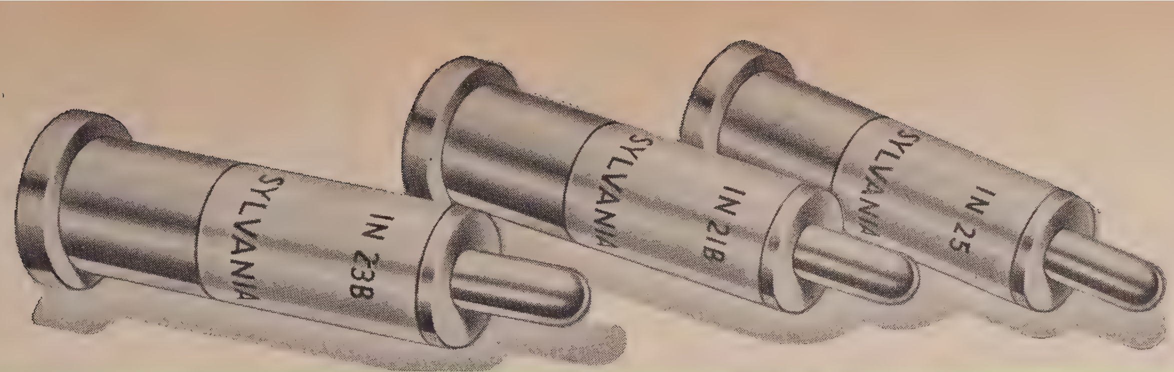
UNIVERSITY OF WYOMING, IRE-AIEE BRANCH

"Electric Power Distribution in Korea," by James G. Force, Student Member AIEE-IRE and General Meeting; January 26, 1954.

"Peterson Coils and their use in Transmission Line Groundings," by John Martin, Public Service Company of Colorado; February 16, 1954.

YALE UNIVERSITY, IRE-AIEE BRANCH

"Submarine Stick Control," by W. E. Chamberlain, Coordinator of Nuclear Projects, Electric Boat Division; February 9, 1954.



FOR BETTER PERFORMANCE SYLVANIA OFFERS NEW MICROWAVE MIXER CRYSTALS

Sylvania announces the addition of a series of new Microwave Mixer Crystals to the world's foremost line.

These new crystals bring simplicity and dependability to many specialized circuit designs. Matched pairs such as the 1N23B and the 1N155 are specially balanced for low-noise operation.

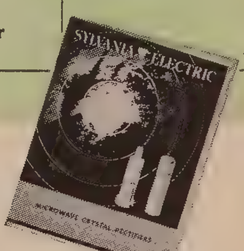
Sylvania also offers Silicon Video Detector Crystals for use as microwave detectors in receivers of the non-heterodyne type. Other quality Sylvania products, engineered for radar and SHF receivers, include Magnetrons, TR Tubes, ATR Tubes, Hydrogen Thyratrons, and Beacon Reference Cavities.

The unbeatable performance of all Sylvania Crystals, Tubes and other components is the direct result of Sylvania's longer experience and continuing advance in the field of electronic research . . . another reason why it pays to specify SYLVANIA!

SYLVANIA SILICON MIXER CRYSTALS

Type	Description	Approx. Freq.
1N21B	S-Band Crystal	3,000 mc.
1N21C	S-Band Crystal	3,000 mc.
1N157	1N21B Reversed Polarity	3,000 mc.
1N23B	X-Band Crystal	10,000 mc.
1N23BM	1N23B Matched Pair	10,000 mc.
1N155	1N23B Reversed Polarity	10,000 mc.
1N156	1N23B matched with 1N155	10,000 mc.
1N23C	X-Band Crystal	10,000 mc.
1N155A	1N23C Reversed Polarity	10,000 mc.
1N23CMR	1N23C matched with 1N155A	10,000 mc.
1N25	L-Band Crystal	1,000 mc.
1N26	K-Band Crystal	24,000 mc.
1N78	K_u-Band Crystal	16,000 mc.
1N53	Classified. Information available upon proper clearance	
1N53M	Classified. Information available upon proper clearance	

SYLVANIA
1N 26
SYLVANIA
1N 53
SYLVANIA
1N 78



Mail the coupon for this booklet describing the complete line of Sylvania Microwave Crystal Rectifiers.

Sylvania Electric Products Inc.
Dept. 4E-3104, 1740 Broadway
New York 19, N.Y.

Please send me new illustrated booklet describing Sylvania's Microwave Crystal Rectifiers.

Name______________________________

Company____________________________

Street______________________________

City_______________Zone______State______

SYLVANIA

Sylvania Electric Products Inc. 1740 Broadway, New York 19, N. Y.

in Canada: Sylvania Electric (Canada) Ltd.
University Tower Bldg., St. Catherine St., Montreal, P. Q.

LIGHTING · RADIO · ELECTRONICS · TELEVISION

Designed for

Application

The No. 10000

WORM DRIVE UNIT

One of our original *Designed For Application* products, tried and proven over the years. Rugged cast aluminum frame may be panel or base mounted. Spring loaded nickel plated cut brass gears work with polished stainless steel worm to provide low back lash. ¼″ diameter stainless steel drive and driven shafts. Available in two ratios, 16:1 and 48:1. Specify ratio in ordering.

JAMES MILLEN
MFG. CO., INC.

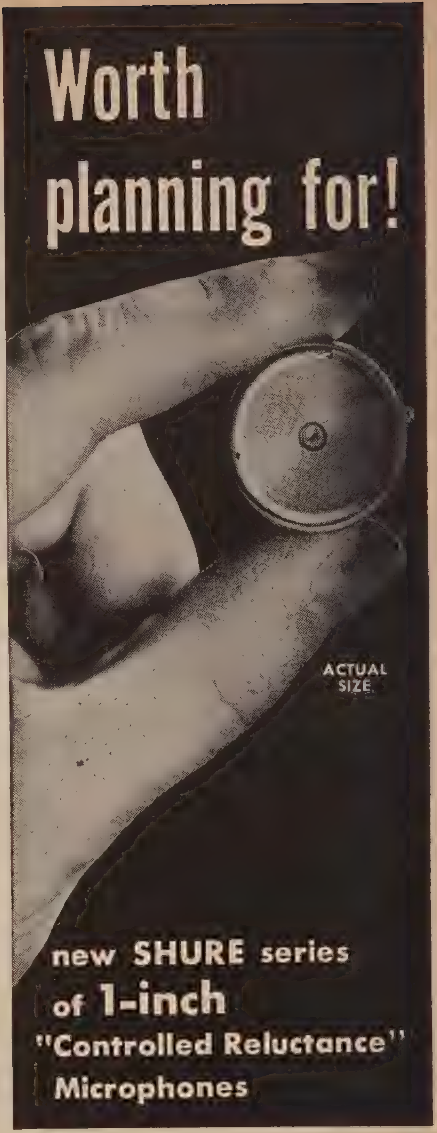
MAIN OFFICE AND FACTORY
MALDEN
MASSACHUSETTS

MEMBERSHIP

The following elections to the Associate grade were approved to be effective as of March 1, 1954:

Abbatiello, J. M., Aura Manufacturing Co., Inc., 119 Chestnut St., New Haven, Conn.
Aceto, L. J., 1438 Spring Rd., N.W., Washington 10, D. C.
Ahmed, A-L. I., 11 Ainmillerstr, Munich 13, Germany
Ainey, R. K., Westinghouse Electric Corp., Box 284, Elmira, N. Y.
Alfieri, G. J., 2305 Boller Ave., New York 69, N. Y.
Allen, E. C., 2815 N. Boston Pl., Tulsa, Okla.
Amara, R. C., 1115 Cedarwood Way, Redwood City, Calif.
Anderson, M. E. E., 116 West 110 St., Chicago 28, Ill.
Andrus, A. M., 23 Main St., Terryville, Conn.
Antonion, G. H., 338 West 47 St., New York 36, N. Y.
Arbuthnott, J., Jr., 30 Beaumont Cir., Tuckahoe, N. Y.
Baart, J. G., c/o W. Treur, 229 MacPherson Ave., Toronto 7, Ont., Canada
Baidya, N. R., 91 Richardson Hall, B.E. College, Howrah, Botanic Garden, West Bengal, India
Bancroft, C., Ferris Hill Rd., New Canaan, Conn.
Baneth, M., Maon David, West Carmel, Haifa, Israel
Barney, W. H., 300 E. Washington St., Bath, N. Y.
Barrett, R. T., 652 Veteran Ave., Los Angeles 24, Calif.
Baskin, E. B., 154 Blackburn Ave., Lansdowne, Pa.
Bates, E. L., 902 Burrstone Rd., Utica, N. Y.
Batson, J. A., RCA Service Co., Ellis & Essex Sts., Gloucester, N. J.
Beard, E. M., 1002 L.G. Group, Norton AFB, San Bernardino, Calif.
Beck, C. L., 2215 Minnesota Ave., S.E., Washington 20, D. C.
Bell, J. E., 1339 Stanton Ave., Whiting, Ind.
Bell, J., Box 404, R.F.D. 4, Barberton, Ohio
Bell, W. C., 3326 Melba Ave., San Diego, Calif.
Benditzky, E., 4520—36 St., N.W., Washington 8, D. C.
Bennett, A. D., 2947 East 45 Pl., Tulsa 15, Okla.
Berberek, W. J., 7338 West 58 St., Summit, Ill.
Berez, I., 6577 Lebanon Ave., Philadelphia 31, Pa.
Bergdahl, R. F., R.F.D. 2, Emporium, Pa.
Berns, K. L., 6825 Glacier Dr., Riverside, Calif.
Bieber, H. P., Jr., 24 East 17 St., Apt. 201, Tulsa, Okla.
Billstein, R. W., 66 N. Columbia St., Woodbury, N. J.
Bird, E. H., 102 Linwood Pl., Fort Lee, N. J.
Bishop, A. B., 2253 Kensington St., Harrisburg, Pa.
Blair, W. W., 204 Grandview Ave., Ithaca, N. Y.
Bodden, A. L., Jr., 4223 Villanova St., Houston 5, Tex.
Bolger, A. E., 2426 W. Second St., Duluth 6, Minn.
Bonav, L. R., 1422 W. Brady, Tulsa, Okla.
Boyd, W. L., 360 N. Bedford Dr., Beverly Hills, Calif.
Bradmiller, R. W., 8622 Mockingbird La., Cincinnati 31, Ohio
Brady, T. D., 483 Fourth St., Brooklyn 15, N. Y.
Brain, B., 282 Cypress Ave., New York 54, N. Y.
Branham, D. W., 122 Cutter Mill Rd., Great Neck, L. I., N. Y.
Branick, B. W., 2025 Oak Ave., Port Arthur, Tex.
Braslau, N., 468 Commonwealth Ave., Boston, Mass.
Brillhart, M. F., 5310 Melvin Dr., Toledo 14, Ohio
Brogdon, L., 1305 North 167 St., Seattle 33, Wash.
Browne, C. W., Box 1101, Lanikai, Hawaii
Brown, R. J., 206 Piercefield Dr., Syracuse 9, N. Y.
Brown, W. R., 200 Hutchinson Blvd., Mount Vernon, N. Y.

(Continued on page 100A)



These Rugged Microphones Make Ideal Components for Small, Compact Equipment

● The new Shure MC Series of 1-Inch "Controlled Reluctance" Microphones were specially designed for use with transistor circuits—and they are highly recommended for use in transistor-type hearing aids. These 1-Inch Microphones are also ideally suited for use in vacuum tube devices such as small, compact Amplifiers, Transmitters, Dictating Equipment—wherever size and weight are factors, and portability is extremely important. The MC Series Microphones normally are furnished with impedance of 1000 ohms (other impedances are available).

The MC Series Microphones are rugged magnetic units, relatively *immune to mechanical shock and to varying conditions of heat and humidity.*

For technical information Write, Wire or Call Sales Division

SHURE

SHURE BROTHERS
INCORPORATED
225 West Huron Street
Chicago 10, Illinois

News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

(Continued from page 82A)

Wire-Wound Controls

An improved version of the $1\frac{1}{8}$ inch diameter (Series 43) wire-wound potentiometer, designated as Series 43c, is announced by **Clarostat Mfg. Co., Inc.,** Dover, N. H.

An improvement is the wiper arm contact and end termination. This contact allows higher resolution, more intricate tapers and tighter tolerances in over-all resistance and linearity. Terminals are directly fastened to winding, insuring low contact resistance. Collector and terminal are now in one piece, eliminating rivets as mechanical fasteners and current conductors. The stop is integral with the base instead of in the cover, insuring a more positive stop, and leaving no holes in cover for dust, moisture, oil, etc., to enter.

Series 43c controls are available in resistance from 1 ohm to 10,000 ohms, 2-watt rating. Taps and various tapers available, with or without switch. Single, dual, and triple assemblies. Choice of shafts. Offered only as initial-equipment units for the present. For more information write for drawing number *251961*.

Vibration Mount

Special engineered mounting systems developed by **Robinson Aviation Inc.,** Teterboro, N. J., are reported to result in reduction of weight, bulk, and cost in electronic equipment. An example is the single-stage mount illustrated, which provides protection against vibration and shock for cylindrical instruments such as an air speed indicator.

Incorporating an all-metal, fabricated cushioning material, Met-L-Flex, this new mounting system offers damping characteristics that result in maximum stability during flight and landing, low overall height facilitating installation in any part of the aircraft, and simplicity of attachment (4 attachment holes for installation).

Robinson claims that with the use of this type of engineered mounting system, airborne instruments and equipment in many instances are now being "deruggedized" and lightened, thus contributing to the desired overall reduction of weight and cost of aircraft.

(Continued on page 110A)

A New Type of D-C Power Source

C&C

STAVOLT®
POWER RECTIFIERS

Closely Regulated by Magnetic Amplifier Control of unique and stable qualities.

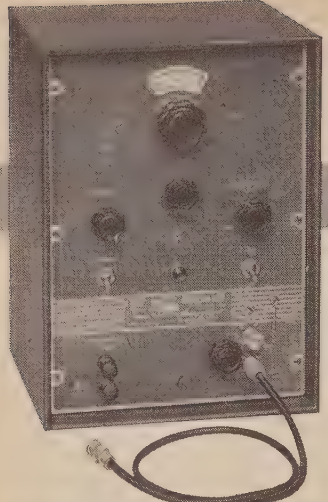
Low Ripple

Fast Response

- Ten standard 28 Volt production models up to 1000 amperes, many others, mobile or stationary.
- Amazing size and weight reduction made possible by use of latest core and insulation materials and aluminum construction.
- Encapsulated components—shock mounted meters recessed behind plastic windows.
- No tubes—lamps—carbon piles—commutators or moving contacts and no radio interference.
- STAVOLT Rectifiers are rugged and can take heavy intermittent overloads. They meet MIL-E-7894 with both range and characteristics.

Engineers will be interested in learning more about the fine qualities of STAVOLT Rectifiers. Write for catalog with detail specifications.

McCOLPIN-CHRISTIE CORP.
3400 West 67th Street, Los Angeles 43, Calif.
25th Year of Rectifier Manufacturing



SPEED UP

factory and service tests!

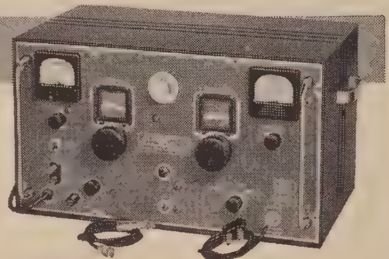
UHF TV SWEEP GENERATOR **MODEL 130**

Features continuous frequency coverage in one band; at least one volt output into 75 ohms; wide sweep; blanked signal on return sweep provides a reference baseline.

SPECIFICATIONS

Freq. Range: 450-900 mc.
Sweep Width: 0-40 mc min.
Sweep: 60 cycle, sine wave.
Output: (1.) 0.1-1.0 volts
(2.) 0.01-0.1 volts approx.

FM SIGNAL GENERATOR **MODEL 100C**



Designed to give precision performance over a single tuning range (27-230 mc). Negligible leakage; low spurious outputs; no auxiliary frequency changer unit required.

Write for specifications and catalog on complete line of measuring equipment.

NEW LONDON INSTRUMENT Company
P.O. BOX 189P
NEW LONDON, CONN.

FOR
MAGNETIC
RECORDING

BRUSH REDHEADS GIVE TOP PERFORMANCE

The high fidelity performance of Brush Redheads has won them wide acceptance from makers of magnetic recording equipment. The record-reproduce head, designed for dual-track recording on ¼-inch tape, has unusually high resolution, which provides an extended frequency range. The Redhead is dimensionally stable, is unaffected by moisture, and provides freedom from microphonics. The companion erase head has the same basic construction, and is outstanding for efficient operation at very low power consumption.

For information on the complete line of Brush magnetic heads—single and multi-channel, write Brush Electronics Company, Dept. F-4, 3405 Perkins Avenue, Cleveland 14, Ohio.

BRUSH ELECTRONICS COMPANY

INDUSTRIAL AND RESEARCH INSTRUMENTS
PIEZO-ELECTRIC MATERIALS • ACOUSTIC DEVICES
MAGNETIC RECORDING EQUIPMENT
ULTRASONIC EQUIPMENT

BRUSH ELECTRONICS

formerly
The Brush Development Co.
Brush Electronics Company is an operating unit of Clevite Corporation.

MEMBERSHIP

(Continued from page 98A)

Brownstein, N., 1521 Fulton Ave., New York 57, N. Y.
Bruce, C. A., 315 Fig Ct., Annapolis, Md.
Bruce, W. D., 777 Clinton Ave., Oradell, N. J.
Brunton, D. A., c/o D. A. Brunton Co., 38 Guinan St., Waltham, Mass.
Bryant, E. F., 14661—18, S.W., Seattle 66, Wash.
Buck, R. D., 440 Maitland St., Bel Air, Md.
Buettner, R. B., 601 Winspear Ave., Buffalo 15, N. Y.
Burch, J. E., Jr., Parker Ave., Madison, Conn.
Burdick, E. E., 371 West 13 St., Idaho Falls, Ida.
Burgener, R. C., 3804 Sequoyah Ave., Knoxville. Tenn.
Carberry, J. F., Photocircuits Corp., New St., Glen Cove, L. I., N. Y.
Cassidy, F. T., 16 Terrace Pl., Brooklyn 18, N. Y.
Casterlin, A. N., R.F.D. 3, Wyoming, Pa.
Cavanaugh, J. T., 10019—116 Ave., S.E., Renton 2, Wash.
Cerf, A. E., 744 Broad St., Newark 2, N. J.
Chadwick, R. F., 4028 Bernice Dr., San Diego 7, Calif.
Chambers, G. A., 4583 E. Clinton Ave., Fresno, Calif.
Chase, R. H., WADC Area B, Box 7838, Wright-Patterson AFB, Ohio
Chevron, R. R., 5220 Lee Rd., Maple Heights, Ohio
Clemente, V. M., 1208 Greene Ave., Brooklyn 21, N. Y.
Cohen, S. H., 64 Lafayette St., Waltham 54, Mass.
Cole, G. W., Box 117, Vineyard Ave., Highland, N. Y.
Coleman, J. V., 680 Steamboat Rd., Greenwich, Conn.
Collins, J. T., 3115 Bracken Woods La., Cincinnati 11, Ohio
Cottone, C. V., Buddington Rd., R.F.D., Groton, Conn.
Cox, G. L., 3080 Lake St., Horseheads, N. Y.
Creed, W. G., 1202 Atwood Rd., Philadelphia 31, Pa.
Crofford, M., 364 Montgomery St., Brooklyn, N. Y.
Cutting, E., 12 Rainbow Rd., Marblehead, Mass.
Dalen, N. N., 1823 Fourth Ave., S., Minneapolis 4, Minn.
D'Amico, V., 74-16 Woodside Ave., Elmhurst 73, L. I., N. Y.
Daniels, J. W., 20961 Garden Gate Dr., Cupertino, Calif.
Davenport, E., 1285 Homer St., Vancouver 3, B. C., Canada
Day, J. B., c/o Government Service Division W2–3, Essex & Ellis Sts., Gloucester, N. J.
DeFries, H. A., 65 Grace Ave., Great Neck, L. I., N. Y.
Derenbecher, W. J., Jr., 1524 Prospect Ridge Blvd., Haddon Heights, N. J.
Derenthal, R. J., 4578 Cape May Ave., San Diego, Calif.
Devane, M. E., 66 Prospect St., West Newton 65, Mass.
DeVita, A. J., 548—17 St., Niagara Falls, N. Y.
Dion, A., 33 De la Ronde, Quebec, Que., Canada
Dolan, F. J., 3 Walnut St., Wakefield, Mass.
Dorchester, R. A., 501 S. Main Ave., San Antonio, Tex.
Doyle, R. E., 31 Hurley Ct., Millbourne, Upper Darby, Pa.
Drago, P., 3922 Daleview Ave., Seaford, L. I., N. Y.
Dreyer, R. F. E., R.F.D. B, Poplarville, Miss.
Dubois, C. L., 3917 Yellowstone Ave., Houston 21. Tex.
Dudek, J. J., 2043 Mayflower Ave., New York 61, N. Y.
Dumaresq, J., 214 Manor Rd., Douglaston, L. I., N. Y.
Eason, C. R., 1109 Sewell Ave., Asbury Park, N. J.

(Continued on page 102A)

DUMONT®
MOBILE
COMMUNICATIONS

like the proverbial distance between two points...

The shortest distance between two points is a straight line – and the best way to bridge that distance is via electronics, for both sight and sound.

The greatest name in *modern electronics* now brings you two-way mobile communications equipment that is scheduled to set new standards of performance, reliability, and value. Du Mont, manufacturers of fine electronic equipment, are now setting the stage for the introduction of mobile communication products designed to fill your needs better.

DU MONT *communications equipment includes:*

MOBILE TRANSMITTERS • RECEIVERS • FIXED STATION EQUIPMENT • REMOTE CONTROL APPARATUS • RELAY CONTROL EQUIPMENT – POINT TO POINT • ALL ALLIED ACCESSORIES FOR EMERGENCY COMMUNICATION SERVICES.

MOBILE COMMUNICATIONS DEPARTMENT
ALLEN B. DUMONT LABORATORIES, INC.
Clifton, New Jersey

another great line of products joins the Du Mont line of quality

- *research*
- *cathode-ray tubes*
- *television broadcasting*
- *television receivers*
- *television transmitters*
- *cathode-ray instruments*

New components, designs and techniques for the Electronics Engineer

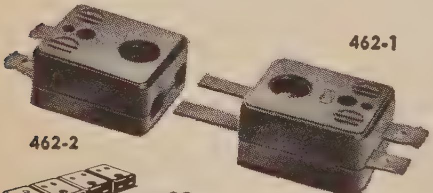
❶ **Solving the problems of high voltage and corona suppression for Color TV**

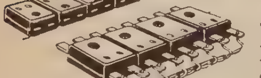
New Alden #220 FTSC 20-pin connector with high-voltage leads completely sealed in polyethylene.

HEAVY JACKET OF MOLDED POLYETHYLENE

Alden High Voltage Anode Cables to handle 20,000 to 30,000 volts. Of polyethylene with integrally molded tube cap of hi-temperature Nylon with extended sleeves; Hi-v. Disconnect completely sealed and with long leakage surface; phosphor bronze Anode Clip. Wide variety available.

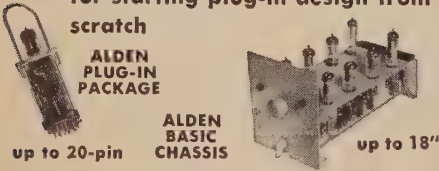
❷ **Adapting electronic designs to Plug-in Unit Construction**





With new Alden Back Connectors equipment becomes slide-in units with single accessible check point for all in-out leads.

❸ **Plug-in Packaging Components for starting plug-in design from scratch**



Here are standard components of tremendous flexibility to assemble your circuitry into plug-in units, and end up with equipment all mounted as illustrated. Will accommodate tremendous variety of circuitry.

❹ **To mount your circuitry in compact vertical planes**

Alden standard components, to mount your circuitry in compact vertical planes as illustrated here, consist of Prepunched Terminal Card, Miniature Staking Terminals, Card-mounting Sockets.

Tell us your area of interest and we'll send Spec. Sheets and details.

NA-ALD **ALDEN PRODUCTS CO.**

4121 N. Main St., Brockton 64, Mass.

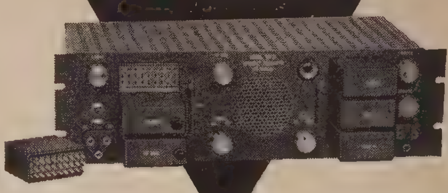
MEMBERSHIP

(Continued from page 100A)

Eddy, H. C., Box 464, Laurel Hill, Fla.
Eisengrein, R. H., 1413 Greenmount St., Rockford, Ill.
Elliott, L. E., Jr., 7815 Edgeway Dr., Houston 24, Tex.
Elser, A. C., 25-69—98 St., E. Elmhurst, L. I., N. Y.
Endo, C. M., 1030 W. Diversey St., Chicago 14, Ill.
Endy, W. M., 48 Greenwood Ave., Oaklyn 6, N. J.
Evans, C. R., 24 Cardinal Pl., Toronto 12, Ont., Canada
Fabricatore, A. J., 413 Autumn Ave., Brooklyn 8, N. Y.
Fallini, G. P., 1512 S. Newport, Tulsa, Okla.
Farrar, J. H., 55 Baker St., Patchogue, L. I., N. Y.
Faytak, A. J., 30-28—159 St., Jamaica 2, L. I., N. Y.
Fittz, R. U., 99 Whitman Ave., Melrose 76, Mass.
Flaherty, J. M., 317 Marose Dr., Pittsburgh 35, Pa.
Flood, F. T., 1539 Comlyst, Philadelphia 49, Pa.
Forman, I., 608 Georgia Ave., Brooklyn 7, N. Y.
Forney, J. F., R.F.D., Buckley Rd., Liverpool, N. Y.
Fortin, C., 6296 First Ave., Montreal 36, Que., Canada
Fox, E. D., 19 E. Chestnut St., Merchantville, N. J.
Frank, R. A., 6725 Thruway, Dundalk 22, Md.
Freestone, H. T., Apt. 2, R.F.D., Buckley Rd., Liverpool, N. Y.
Friedman, A. L., Rm. H-386, Massachusetts Institute of Technology, Cambridge 39, Mass.
Fritz, E. L., International Business Machines Corp., Box 390, Poughkeepsie, N. Y.
Fulliero, R., 40 W. Clay St., Waterbury, Conn.
Fulton, D. S., 304 S. Beech St., Centralia, Ill.
Gambuti, P. F., 73 Redneck Ave., Little Ferry, N. J.
Game, L. C., 50 Parkhome Ave., Willowdale, Ont., Canada
Garrett, C. L., 208 W. Greenwood Rd., Linthicum Heights, Md.
Genzlinger, V., Box 188, Huntington Valley, Pa.
Gibson, C. B., Jr., 41 Ehrbar Ave., Mount Vernon, N. Y.
Gichtin, A. L., 1338 S. Beverly Glen Blvd., Los Angeles 24, Calif.
Gildart, L. W., 133 Coit St., Irvington 11, N. J.
Gillies, G. A., 105 Yorkminster Rd., Willowdale, Ont., Canada
Gilmore, W. C., 19 E. Chestnut Ave., Merchantville, N. J.
Gjertsen, E. J., 1355 N. Menard Ave., Chicago 51, Ill.
Golden, T. S., Jr., 612 Galveston Pl., S.E., Washington 20, D. C.
Gomez, P. D., 7-21 Alameda Dr., Oxnard, Calif.
Gorman, V. R., R.F.D. 1, Prospect Park, Emporium, Pa.
Graham, H. L., 1006 Buffalo, Cleburne, Tex.
Greening, J. P., Box 428-21, R.F.D. 1, Bartlesville, Okla.
Gunsten, R. T., 1572 Tyler St., Akron 20, Ohio
Gustafson, A. J., Jr., Box 574, Yorktown, Va.
Hackenyos, C. W., c/o General Electric Co., 1405 Locust St., Philadelphia 2, Pa.
Halio, M., 716 Commerce St., Havre De Grace, Md.
Hall, J. J., Box 97, Alpha, Ohio
Hammond, R. L., Box 661, Huntsville, Ala.
Hanes, F. P., 414 Marshall Walk, Louisville 14, Ky.
Harrington, E. W., 571 Turnpike St., Shrewsbury, Mass.
Hauser, G. G., 3110 Brackenwoods La., Cincinnati 11, Ohio
Hawes, R. B., 28 Abbott St., Nashua, N. H.
Heinlein, J. V., 343 Wall St., Eatontown, N. J.
Heist, H. E., Jr., 1937 Derry St., Harrisburg, Pa.
Hercules, W. P., 1714 Locust St., Kansas City 8, Mo.

(Continued on page 104A)

PIPELINE TO PRECISION



MODEL WWVR

A receiver of the instrument class which is setting a new standard for the reception and presentation of the world's finest standards of time and frequency as broadcast by the National Bureau of Standards from WWV and WWVH.

The fundamental use of this receiver is in the calibration of local equipment to the accuracy of these primary time and frequency standards.

This time saving instrument incorporates all the latest techniques for clear reception. A glance at the front panel will at once show the ease of operation and instant availability of the desired Radio and Audio frequencies.

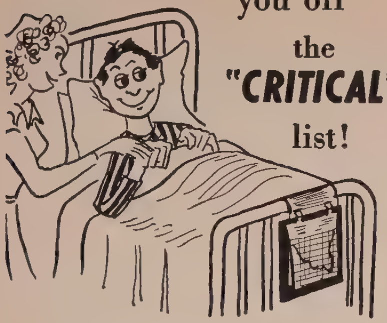
Model WWVR allows the operator full use of the world's finest primary standards of frequency and time. All frequencies broadcast from WWV (or WWVH) are accurate to one part in fifty million. This instrument in your laboratory will truly give you a...

PRIVATE PIPELINE TO PRECISION.

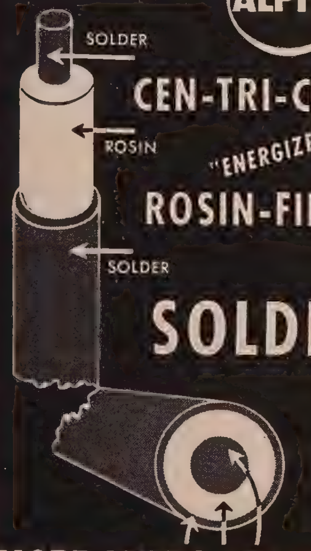
Send for complete specifications, prices and delivery schedule.

SPECIFIC PRODUCTS
14515 DICKENS STREET
SHERMAN OAKS 2, CALIF.

ALPHA will take
you off
the
"CRITICAL"
list!



NO VOIDS*
MORE ECONOMICAL
LESS WASTE
with ALPHA



CEN-TRI-CORE
"ENERGIZED"
ROSIN-FILLED
SOLDER

MORE JOINTS PER POUND WITH CEN-TRI-CORE

Exclusive Features

* guarantees against rosin voids or skips
- eliminates cold joints and rejects
- available in eight core sizes
- solders to plated or oxidized parts
- simultaneous "wetting flow" and take
- surpasses federal specifications for non corrosiveness and purity
- thin walls insure rapid heat transfer and faster fluxing action.

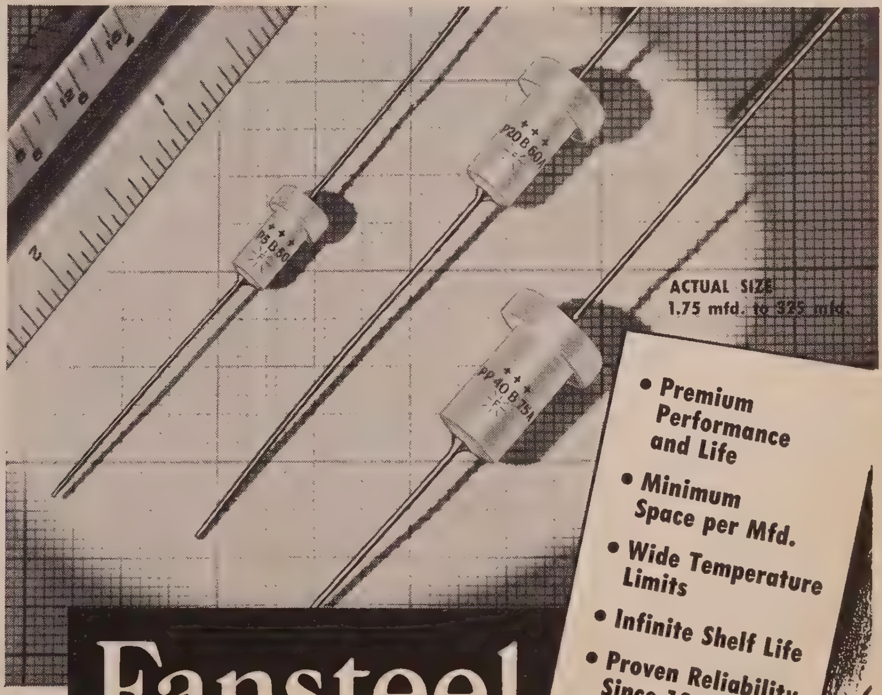
for further
information
write . . .

FASTER MELTING · POSITIVE FLUXING

ALPHA METALS, INC.
61 Water St., Jersey City 4, N. J.
Specialists IN SOLDER For Over 50 Years

TANTALUM CAPACITORS...

...basic in current electronic trend..



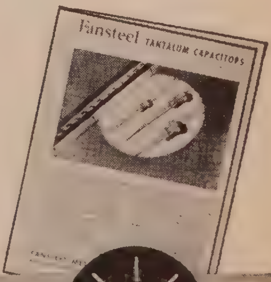
ACTUAL SIZE
1.75 mfd. to 325 mfd.

- Premium Performance and Life
- Minimum Space per Mfd.
- Wide Temperature Limits
- Infinite Shelf Life
- Proven Reliability Since 1930

Fansteel
TANTALUM CAPACITORS

Now, through the use of tantalum, new high standards of electrolytic capacitor performance are available. The tantalum oxide film is the most stable dielectric, chemically and electrically, yet discovered. As a result, Tantalum Capacitors offer advantages not found in any other electrolytic type — long life, space saving, wide temperature range excellent frequency characteristics, no shelf aging.

Tantalum Capacitors are made by Fansteel and other leading capacitor manufacturers. Ask for current information bulletins on Fansteel Tantalum Capacitors.



FANSTEEL METALLURGICAL CORPORATION
NORTH CHICAGO, ILLINOIS, U. S. A.
Tantalum Capacitors... Dependable Since 1930

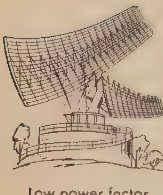
32503C

TEFLON* CAN *improve your products!*

JOHN CRANE The best in TEFLON

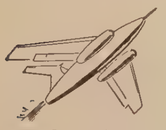
Exceptional qualities of "JOHN CRANE" TEFLON make it highly desirable for a wide range of equipment and parts lines. Manufacturers of precision equipment and component parts cannot overlook its remarkable electrical, thermal, mechanical and anti-corrosive advantages. Note Teflon's outstanding properties and characteristics.

*DuPont Trade-mark for tetraflouro-ethylene resin



Low power factor high dielectric strength

ELECTRICAL PROPERTIES: Power factor less than 0.0005 over the entire spectrum from 60 cycles to 30,000 megacycles, with a dielectric constant of between 2.00 and 2.05 • Short-time dielectric strengths from 1,000 to 2,000 v., per mil in thickness of 5-12 mils • High resistance to surface arc • Volume resistivity greater than 10^{15} ohm-cm • Surface resistivity drops to only 10^{13} ohms at 100 percent relative humidity.

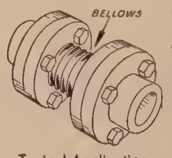


Outstanding thermal characteristics

THERMAL AND MECHANICAL PROPERTIES: Tensile strength 1,500 to 2,500 psi. at 77 deg. F. • Durometer hardness 55 to 70 • Stiffness 60,000 psi. at 77 deg. F. • Friction coefficient against polished steel (static) .09 —.12 • Remains flexible down to −94°F. Serviceable up to +482°F.

Corrosion resistant

ANTI-CORROSIVE PROPERTIES: Resists all chemical liquids and gases except molten alkali metals and fluorine and chlorine trifluoride • No detectable changes in properties over 1-year outdoor weather test • Zero water absorption.



Typical Application

TYPICAL APPLICATIONS: For such applications, as vhf, uhf, or high voltage—high temperature insulator forms, heat-resistant linings, oil and firewall seals, gaskets, valve discs or seats, packings, flexible bellows, diaphragms, slot liners, heat sealer jaws and dough rollers. Let our engineers fit "JOHN CRANE" TEFLON to your specific needs.

"JOHN CRANE" TEFLON parts can be manufactured to your specifications. Investigate now. Let us know your requirements. Send for our 12-page illustrated catalog.
Crane Packing Company, 1803 Belle Plaine Ave., Chicago 13, Ill.

JOHN CRANE **CRANE PACKING COMPANY**

Membership

(Continued from page 102A)

Herriott, J. K., Jr., 5-J Chatham Apts., Savannah, Ga.
Higgins, H., Jr., Box 95, Coweta, Okla.
Hodge, R. M., R.F.D. 1, Maplewood, Ohio
Hollister, A. R., 159 Naubuc Ave., East Hartford 8, Conn.
Holt, J. F., R.F.D. 1, DuPont Rd., Fort Wayne, Ind.
Honeck, H. C., 78 Burke St., East Hartford, Conn.
Hoover, W. C., Standard Crystal Co., 1714 Locust St., Kansas City 8, Mo.
Horan, E. F., Philco Corp., Tech-Rep. Division, 22 & Lehigh, Philadelphia 32, Pa.
Howe, D. R., 4156 Edgemere Ct., Apt. E-1, Indianapolis, Ind.
Huber, C. E., Johns Hopkins University, Applied Physics Laboratories, 8621 Georgia Ave., Silver Spring, Md.
Ikrath, K., 31 Cedar Ave., Apt. 12, West End, N. J.
Intini, A. V., Jr., 658 North St., Rochester 5, N. Y.
Isaacs, R. A., 1010 Edann Rd., Oreland, Pa.
Jackamonis, G., 30 Alt Blvd., Grand Island, N. Y.
Jensen, T. F., 68 William St., East Orange, N. J.
Judge, W. J., 107 B Glenwood Ave., East Paterson, N. J.
Karas, J. P., 40-26—69 St., Woodside 77, L. I., N. Y.
Kassel, C., 2028 Brown St., Brooklyn 29, N. Y.
Kates, W. A., 37A Dehon St., Revere, Mass.
Keller, T. B., Jr., 118 W. Park Ave., Hubbard, Ohio
Kelley, O. G., Devonshire Rd., R.F.D. 87, Harrisburg, Pa.
Kim, J. C. S., 106 Haven Rd., University Heights, Syracuse 10, N. Y.
Kimmel, E. J., 1807 Hartman Ave., Louisville 5, Ky.
King, D. L., 3974 Sawtelle Blvd., Culver City, Calif.
King, W. F., RCA Service Co., W2-2, Gloucester, N. J.
Kingwill, H. S., Jr., 35 E. Wacker Dr., Chicago 1, Ill.
Kistler, R. J., c/o Newkirk, 1633 New Holland Pike, Lancaster, Pa.
Kivimaki, V. C., 20084 Lahser Rd., Detroit 19, Mich.
Kleeger, A. A., 173 Fifth Ave., Ottawa, Ont., Canada
Klein, W., 1472 Earlham Dr., Dayton 6, Ohio
KnicKrehm, A. F., 1210 Coronet Ave., Pasadena 8, Calif.
Koenis, W., 180 Varick St., New York 14, N. Y.
Kolb, J. A., 659 Lowell St., Westbury, L. I., N. Y.
Kowalski, L. E., 17165 Anglin Ave., Detroit 12, Mich.
Kuntz, G. L., 1469 Hickory, Bartlesville, Okla.
Lamoureaux, R. A., Jr., 15 Avenue A, North Adams, Mass.
Lampert, S. R., 1901 Frieze, Ann Arbor, Mich.
Langille, R. C., 30 Glencairn Ave., Ottawa 1, Ont., Canada
Lapointe, J., 535-10 Avenue O, Charny, Que., Canada
Law, L. R., 16732 Jersey St., Granada Hills, Calif.
Lawrence, S. C., Jr., 13734—12 St., S.W., Seattle 66, Wash.
Leeder, J., R.F.D. 2, Aberdeen, Md.
Legum, A. G., c/o Tri-City Radio Corp., Box 271, Muncie, Ind.
Lemly, F. W., 40 Wall St., New York 5, N. Y.
Lending, R. D., 61 Pemberton Ave., Oceanport, N. J.
Leopold, J. M., Electronics Office, Staff ComFair Japan, c/o FPO, San Francisco, Calif.
Letzter, A. O., 1720 Nostrand Ave., Brooklyn 26, N. Y.
Lienhard, T. G., 7719 Hatton Pl., Reseda, Calif.
Lindberger, N. A., IBM Gavlegatan 20, Stockholm 6, Sweden
Lineback, J. T., 10655 Cayuga Dr., Dallas, Tex.
Lippman, L., 3924 E. Second Ave., Tulsa 12, Okla.
Loomis, W. E., 1033 E. Saint Joseph St., Lansing 12, Mich.

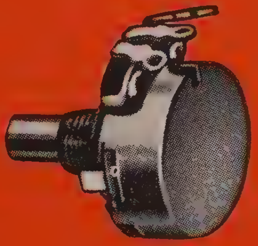
(Continued on page 108A)

COMPLETE MILITARY LINE

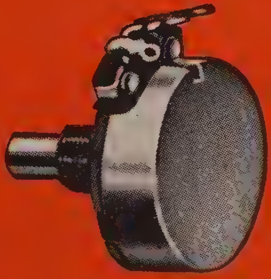
Immediate delivery from stock on 189 types including JAN-R-94 and JAN-R-19 types of variable resistors.

NEW 38-PAGE ILLUSTRATED CATALOG—
Describes Electrical and Mechanical characteristics, Special Features and Constructions of a complete line of variable resistors for military and civilian use. Includes dimensional drawings of each resistor. *Write today for your copy.*

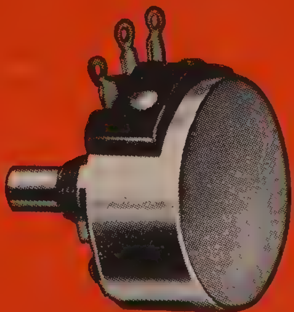
TYPE 45, (JAN-R-94, Type RV2)
1/4 watt, 15/16" diameter variable composition resistor. Also available with other special military features not covered by JAN-R-94 including concentric shaft tandem construction. Attached switch can be supplied.



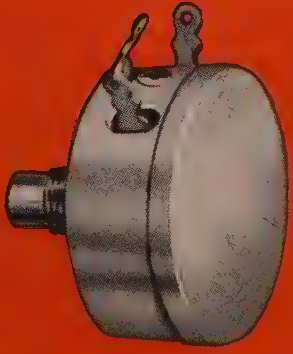
TYPE 35, (JAN-R-94, Type RV3)
1/2 watt, 1 1/8" diameter variable composition resistor. Also available with other special military features not covered by JAN-R-94 including concentric shaft tandem construction. Attached switch can be supplied.

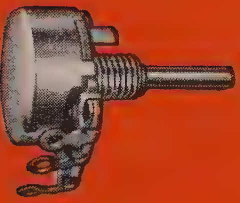


TYPE 252, (JAN-R-19, Type RA20)
2 watt, 1 17/64" diameter variable wirewound resistor. Also available with other special military features not covered by JAN-R-19 including concentric shaft tandem construction. Attached switch can be supplied.

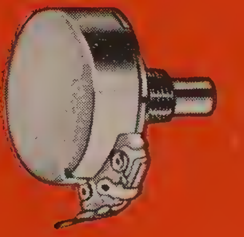


TYPE 25, (JAN-R-19, Type RA30)
(May also be used as Type RA25)
4 watt, 1 17/32" diameter variable wirewound resistor. Also available with other special military features not covered by JAN-R-19 including concentric shaft tandem construction. Attached switch can be supplied.

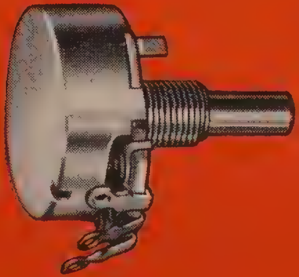




TYPE 65, (Miniaturized)
1/2 watt 70°C, 3/4" diameter miniaturized variable composition resistor.



TYPE 90
1 watt 70°C, 15/16" diameter variable composition resistor. Attached switch can be supplied. Also available in concentric shaft tandem construction.



TYPE 95, (JAN-R-94, Type RV4)
2 watt 70°C, 1 1/8" diameter variable composition resistor. Also available with other special military features not covered by JAN-R-94 including concentric shaft tandem construction. Attached switch can be supplied.

UNPRECEDENTED PERFORMANCE CHARACTERISTICS

Specially designed for military communications equipment subject to extreme temperature and humidity ranges. −55°C to +150°C...aridity to saturation.

CTS

CHICAGO TELEPHONE SUPPLY
Corporation

ecision Mass Production of Variable Resistors

it's VARIAN...
for top performance in every KLYSTRON application

System designers and equipment buyers specify Varian klystrons for optimum performance because they know that **only** Varian klystrons combine extreme ruggedness and reliability with excellent frequency stability and ample power. Designed and built by the acknowledged leader in klystron development, Varian klystrons offer outstanding performance advantages in these and many other applications:

- Microwave relay transmitters and receivers
- Telemetering systems
- UHF television transmitters
- Radar receivers—local oscillators
- Coherent and pulsed radar transmitters
- Guided missile applications
- Microwave test equipment
- Particle accelerators—power tubes

COMPARE THESE FEATURES

FOR RADARS AND BEACONS

Unmatched high altitude performance **without** pressurization—excellent frequency stability — low noise — rapid warm-up — rugged — reliable.

FOR MICROWAVE RELAY SYSTEMS

Ample power to override noise—excellent frequency stability—economy of operation—long life.

FOR LABORATORY TESTING

Smooth, single-shaft tuning over a wide range—matched waveguide output—excellent microphonic characteristics—linear reflector tracking.

FOR UHF TELEVISION

Integral cavity construction for economical operation and simple installation—wide band-width for color TV—high power gain —long life.

VARIAN HAS A PRODUCTION KLYSTRON...

that meets the requirements of these typical applications:

APPLICATION	FREQUENCY RANGE (Megacycles)	POWER RANGE	TUBE TYPES
Radar & Beacon Local Oscillators	8500 — 10,500	25 — 140 mw	V-270, V-290, V-151, V-153, V-155
Radar Transmitters	8500 — 11,000	100 W — 9 KW	V-23, V-63, V-27, V-82, V-45
Beacon Transmitters	9100 — 12,200	450 mw — 9 KW	V-54, V-63, V-27, V-82, V-45
Relay Local Oscillators & Transmitters	5100 — 7500	30 mw — 1 W	X-26B, X-26D, X-26E, X-26F
UHF Television	470 — 890	15 KW	VA-6237, 38, 39, 40, 41 and 42
Laboratory Testing	8200 — 12,400	450 mw — 8 W	X-13, V-21, V-27, V-54, V-58

FOR COMPLETE SPECIFICATIONS and technical data on these outstanding Varian klystrons, and for information about special purpose klystron engineering—write to the VARIAN Application Engineering Department today.

IN KLYSTRONS, THE MARK OF LEADERSHIP IS
VARIAN associates
PALO ALTO 2, CALIFORNIA

MEMBERSHIP

(Continued from page 104A)

MacDonald, F. H., 309 W. Shady Grove Rd., Irvington, Tex.
Macune, C. W., 3132 Forest Park Blvd., Fort Worth, Tex.
Maddox, J. A., 103 Bald Cypress La., Levittown, Pa.
Mahaffy, J. D., 1175 Grosvenor Ave., Winnipeg, Man., Canada
Mancini, R. A., 1949 Carmen Ave., Los Angeles 28, Calif.
Mathias, J. P., JPM Co., Lewisburg, Pa.
Matthews, C. R., 710—95 St., Houston 12, Tex.
Maxwell, J., 86 Delemere Ave., Toronto 9, Ont., Canada
Mayo, B. R., 209 Landon Ave., Syracuse, N. Y.
Mazzagatti, R. P., 813 N. Second, Bellaire, Tex.
McClure, D. H., 9035 Ramsgate Ave., Los Angeles 45, Calif.
McGrath, E. F., 3609 W. 15 Ave., Vancouver 8, B. C., Canada
McKnight, C. L., 2832 Arnott St., San Diego 17, Calif.
McKnight, **W. H.**, Corning Glass Works, Corning, **N. Y.**
McSherry, J. H., 3428 Geraldine Ave., St. Louis 15, Mo.
Mendus, W. M., 300 Calvert Ave., Alexandria, Va.
Mercado, P. D., 55 Lindbergh Ave., Broomall, Pa.
Miller, L. S., Sheridan Rd., R.F.D. 12, Fort Wayne, Ind.
Miller, R. A., 4320 S. Owasso, Tulsa, Okla.
Milton, J., 3 Henry St., Great Neck, L. I., N. Y.
Minton, J. A., Jr., Box 466 AD, R.F.D. 2, Dallas, Tex.
Misch, F. E., 4917 S. Madison, Tulsa 5, Okla.
Mondschein, M., 243 B—141 St., Belle Harbor, L. I., N. Y.
Montague, N. C., 9301 TSU-ORD BRL, DET., Aberdeen Proving Ground, Md.
Mottel, S., 121 Clarke Pl., New York, N. Y.
Mulvey, J. A., 7428 N. 21 St., Philadelphia 38, Pa.
Neely, J. C., Vitro Corporation of America, 962 Wayne Ave., Silver Spring, Md.
Neff, A. K., Stackpole Carbon Co., St. Marys, Pa.
Nelson, W., 1411 Park Pl., Brooklyn 13, N. Y.
Neuwirth, K. R., 1204 Mercer Ave., Akron 7, Ohio
Niemann, E., Jr., R.F.D. 2, Ballston Lake, N. Y.
Nixon, P. E., Bell Aircraft Corp., Buffalo, N. Y.
Nobles, F. L., 447 Central St., Holliston, Mass.
Nowicki, J. R., 40 Ansell Rd., London, S.W. 17. England
Oberg, E. A., 1205 Fourth Ave., San Francisco 22, Calif.
O'Brien, J. G., 6913 Avenue K, Houston 11, Tex.
O'Connell, E. D., 666 San Antonio Way, Sacramento, Calif.
Okuna, T. M., 4717 Kenwood Ave., Chicago 15, Ill.
Ordonia, J. M., ACS P.O. Box 219; Anchorage, Alaska
Packard, R. F., 6123 MacBeth Dr., Baltimore 12, Md.
Paddock, J. A., IBM Laboratory Annex, Poughkeepsie, N. Y.
Pape, A. E., 560 E. Ford Ave., Barberton, Ohio
Paul, C. H., 34 Hix Ave., Rye, N. Y.
Pendleton, L. S., 135 Payran St., Petaluma, Calif.
Perletti, P. V., 6021 Redwing Ave., Seattle 8, Wash.
Perlini, R., 2 Lorraine Blvd., Poughkeepsie, N. Y.
Petersen, H. J., 432 Van Dyke Ave., Haledon, N. J.
Pickens, H. V., 2750 Bradford Dr., Toledo 14, Ohio
Pinz, B. M., 2201 Amsterdam Ave., New York 32. N. Y.
Poletti, G., 397 Highland Ter., Orange, N. J.
Porter, H. D., Box 464A, R.F.D. 4, New Brunswick, N. J.
Postel, H., 24 Ponder La., Levittown, L. I., N. Y.
Purdy, W. E., 23 Lancaster La., Norwood, Mass.
Quinn, J. C., Jr., A. Kimball Co., 307 W. Broadway, New York 13, N. Y.

(Continued on page 132A)

USE US FOR FAST FOOT WORK

Modern research makes things change fast. Your very size of production concentration may hamper the "dexterity of your foot work."

We, being smaller, with all around experience, may be able to aid you in quick movements to keep up with progress.

Use us for mobility.

CONRAD & MOSER

Workers in Aluminum, Brass, Steel & Plastics

DESIGNING
ENGINEERING • MANUFACTURING
MECHANISMS • MACHINES
PARTS • TOOLS • DIES • MOLDS
STAMPINGS • CASTINGS
MACHINING • SHEET METAL
ENCLOSURES & CHASSIS
⅛ to ⅛ NAVY SPEC ALUMINUM
SPOT WELDING AND HELIARC
WELDING.

2 Borden Ave.
Long Island City 1, N.Y.

CONRAD & MOSER • ESTABLISHED 1925 • APPLIED PRECISION

MAXIMUM STABILITY

✓ Where constants depend on unvarying capacity

Stabelex® "D" Capacitors

For Precision Circuitry in:

U.H.F. Components
Wave Shaping and Pulsating Circuits
RC Circuits
Countless Other Electronic and Industrial Uses

Industrial Condenser Corp. can design, engineer, or, in most cases, meet your capacitor requirements directly from stock. Send now for Catalog 1117. Complete with performance curves, characteristics and suggested applications, this valuable booklet should be in your file for instant reference.

Outstanding Operating Characteristics

Insulation resistance at +20°C. after three minutes charge: 900,000 megohm microfarads

Insulation resistance at +75°C.: 78,000 megohm microfarads

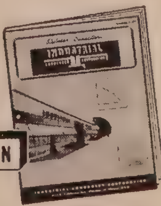
Insulation resistance at −75°C.: In excess of one million megohm microfarads

✓ **Change in capacitance** from +25°C. to −80°C.: +0.76%

Self time constant of 10 mfd. capacitor: 4800 hours

Q at 50 kilocycles: 10,000

Power Factor at 1 kc: 0.00025



INDUSTRIAL CONDENSER CORPORATION

3247 N. CALIFORNIA AVE., CHICAGO 18, ILLINOIS

DECADE RESISTANCES & VOLTAGE DIVIDERS

delivered from stock

Accuracy: 10 ohms and above: ±0.1%
1 ohm: ±0.25%
0.1 ohm: ±1%
0.01 ohm: ±5%

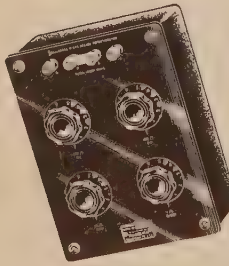
Temp. Coeff.: ±0.002% per degree C.
Maximum Load: ½-watt per step
Frequency Limit: Non-inductive to 20KC

DECADE RESISTANCE BOXES

Type	Dials	Ohm Steps	Total Resistance—Ohms	Price
817	3	0.01	11.1	$60.00
818	3	0.1	111	51.00
820	3	1	1,110	56.00
821	3	10	11,100	60.00
822	3	100	111,000	63.00
823	3	1,000	1,110,000	77.00
824	3	10,000	11,100,000	120.00
817-A	4	0.01	111.1	75.00
819	4	0.1	1,111	71.00
825	4	1	11,110	77.00
826	4	10	111,100	79.00
827	4	100	1,111,000	92.00
828	4	1,000	11,110,000	139.00
8285	5	0.1	11,111	94.00
829	5	1	111,110	101.00
830	5	10	1,111,100	113.00
831	5	100	11,111,000	155.00
817-C	6	0.01	11,111.1	105.00
8315	6	0.1	111,111	109.00
832	6	1	1,111,110	121.00
833	6	10	11,111,100	169.00

UNMOUNTED DECADE RESISTANCES

Type	Dials	Ohm Steps	Total Resistance—Ohms	Price
435	1	0.1	1	$12.00
436	1	1	10	13.25
437	1	10	100	13.25
438	1	100	1,000	15.00
439	1	1,000	10,000	16.00
440	1	10,000	100,000	18.50
441	1	100,000	1,000,000	32.50
442	1	1,000,000	10,000,000	60.00



DECADE VOLTAGE DIVIDERS (Potentiometers)

Type	Dials	Ohm Steps	Total Resistance—Ohms	Price
845	3	1	1,000	98.00
837	4	0.1	1,000	126.00
835	4	1	10,000	132.00
836	4	10	100,000	146.00

SHALLCROSS MANUFACTURING COMPANY
524 Pusey Ave., Collingdale, Pa.

Shallcross
Our 25th Year 1929 1954

News—New Products

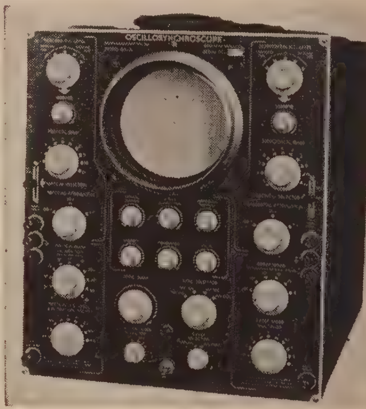
These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

(Continued from page 99A)

CORRECTION NOTICE

Oscillosynchroscope

Browning Laboratories, Inc., 750 Main St., Winchester, Mass., announces their Model OA-16 Oscillosynchroscope, featuring a calibrated buck-out voltage which allows balancing out of dc levels accurately to 10 per cent. This enables small superimposed ac signals to be expanded for more minute inspection of both the signal and small changes in dc level. This represents a possible 40:1 expansion of the signal over that observable using conventional dc methods.



Also featured are vertical and horizontal amplifier band-widths from dc to 5 mc and 1 mc, and sensitivities of 50 mv, peak-to-peak, per inch and 120 mv, peak-to-peak, per inch, respectively. Triggered or recurrent sweeps from 0.4 μsec/cm to 10 seconds total sweep time are available. A video delay line permits observation of rising wavefronts of pulses.

Amplitude measurement may be made through use of a 60 cps square-wave which adequately covers any deflection range with an accuracy of 5 per cent.

Thermistor Data Sheets

Information on methods of using Thermistors, heat-sensitive electrical resistors with negative temperature coefficient, as well as a description of a new physical demonstration of permanent magnet properties, is available in a number of technical data sheets issued by **Carboloy Dept., General Electric Co.,** Detroit 32, Mich.

The reports describe Thermistor applications in radio set surge protection (data sheet TH-11), contactless switches in over-load protective devices (data sheet TH-11), temperature compensation (data sheet TH-10), warning signals (data sheet TH-9), and controlled automation (data sheet TH-9). They each include manufacturing, operating, selection and engineering data.

(Continued on page 123A)

Positions Wanted

(Continued from page 122A)

SALES ENGINEER

BS, MS in EE, 2 years in headquarters sales negotiating contracts for large eastern electrical company. Age 28, unmarried. Desires direct selling position in southeast. Box 726 W.

ENGINEER

BSEE; recent M.B.A. (Ind. Mgt.). 6 years experience, largely technical, with some administration and customer contact. Desires work in administration, sales or product development. Prefer western U. S. location. Box 744 W.

News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

(Continued from page 110A)

Helical VHF TV Antenna

The **General Electric Co.,** Electronics Park, Syracuse, N. Y., has announced that it will supply the first helical antenna for VHF television broadcasting to stations WHEC-TV, which are to share channel 10 in Rochester, N. Y.

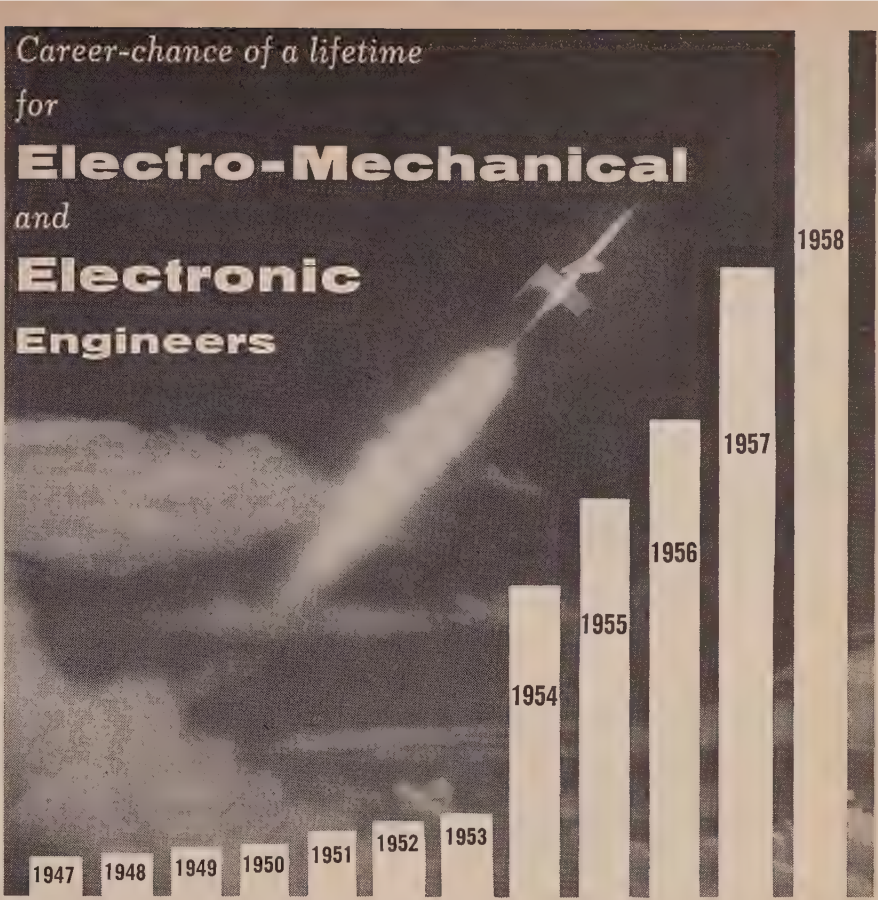
The Rochester stations will operate from separate studios, but share a common transmitter and antenna. They expect to begin operations Nov. 1, using a General Electric 5-kilowatt transmitter and one-bay batwing antenna on an interim basis. The new helical antenna is scheduled for delivery next spring, at which time the station will place in operation a 20-kilowatt G-E transmitter amplifier.

The stations are authorized to operate with an effective radiated power of 120 kw. They anticipate their coverage area will extend over a 60-mile radius when full power is attained.

The antenna's design permits it to actually replace the upper 36-feet of the present tower, (owned by WHAM-TV) with the WHAM-TV six-bay channel 5 antenna mounted on top of the helical unit. There are only two feed points for the new G-E antenna, permitting feed lines for both antennas to be carried with the helical unit.

The 7.2 gain of the helical antenna for WVET-TV and WHEC-TV will be attained with only two bays. Additional bays and higher gains are possible. The antenna will be 36-feet long, and the helix about 38-inches in diameter. Its cylindrical construction reduces wind loading, and in future installations would result in more economical tower construction.

(Continued on page 126A)



Your career can go up

with Lockheed's expanding Missile Systems Division

■ Outstanding career opportunity comes rarely in a man's life. But such an opportunity exists now for Electro-Mechanical and Electronic Engineers in Lockheed's Missile Systems Division.

■ Recently formed from other Lockheed engineering organizations, the Missile Systems Division is in a stage of dynamic expansion. For Electro-Mechanical and Electronic Engineers of ability, experience and initiative this is an unparalleled opportunity for advancement and achievement. A number of present openings are on a high executive level.

The openings are for

ELECTRO-MECHANICAL ENGINEERS
with circuit or servomechanisms experience (aircraft or missile experience preferred)

ELECTRONIC ENGINEERS
experienced in any or all of the following fields: Micro-Wave Techniques, Electronic Components, Circuit Design, Flight Instrumentation

■ In addition to outstanding career opportunities, the Lockheed Missile Systems Division offers you excellent salaries commensurate with your experience, generous travel and moving allowances, and a better life for you and your family in Southern California.

Coupon is for your convenience

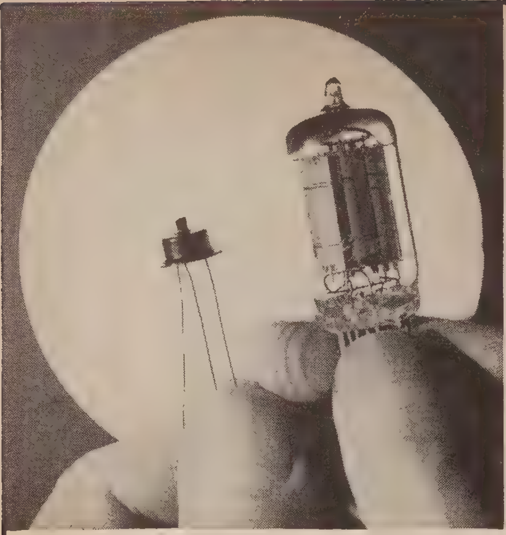
Mr. L. R. Osgood • Dept. IRE-M-4
LOCKHEED MISSILE SYSTEMS DIVISION
7701 Woodley Avenue • Van Nuys, California
Dear Sir: Please send me information on the Missile Systems Division.

my name

my field of engineering

my street address

my city and state



General Electric hermetically-sealed, evacuated junction transistor (left), contrasts sharply with standard miniature vacuum tube.

GENERAL ELECTRIC OFFERS OPPORTUNITIES TO . . .

ENGINEERS
PHYSICISTS
CHEMISTS

WORK ON THE NEW DEVELOPMENTS IN ELECTRONICS AS AN ENGINEER WITH GENERAL ELECTRIC

Few developments today can match the importance and versatility of the tiny transistor, which has vast possibilities for both industrial and consumer use.

General Electric engineers are at work now on new improvements, new applications and advances. As always, they are aided by the finest facilities . . . by the cooperation and encouragement of recognized leaders in the field . . . by the opportunity to take on increasingly challenging assignments.

These factors, combined with stability, excellent salary and benefits, provide the engineer with the ideal environment for achievement and growth.

Experience required in the following fields:

Advanced Development, Design, Field Service and Technical Writing in connection with:

MILITARY RADIO & RADAR
MOBILE COMMUNICATION
MULTIPLEX MICROWAVE COMMUNICATIONS
ELECTRONIC COMPONENTS
TELEVISION, TUBES & ANTENNAS

Bachelor's or advanced degrees in Electrical or Mechanical Engineering, Physics, Metallurgy or Physical Chemistry and/or experience in electronics industry necessary.

Please send resume to: Dept. 4-4-P, Technical Personnel

GENERAL ELECTRIC

ELECTRONICS PARK, SYRACUSE, N. Y.

NEW HORIZONS

Today's horizons in electronic engineering are limited only by the vision of the individual himself. To those qualified men who desire to stand on the constantly changing frontiers of electronic development, we offer a chance to pioneer and grow with a soundly-established, yet young and progressive company.

- **Electronic Field Engineers**

Local and Field Assignments Available

At least 5 years' experience in any *one* of these fields: Servo Mechanisms; Special Weapons; Microwaves; Antennas; Circuit Design; Flight Simulators; Radio Propagation; Electronic Computers and Communications.

Qualified to instruct in the operation and supervise installation, maintenance and repair of Radar, Sonar, Flight Simulators and allied electronic equipment in the field.

Salary and advancement commensurate with ability; liberal vacation, sick leave, 9 paid holidays, group life, sickness and accident insurance plans, and a worthwhile pension system.

STAVID
Engineering, Inc.
Personnel Office, 312 Park Avenue
Plainfield, N.J.—PLainfield 6-4806

PHYSICISTS

RESEARCH ENGINEERS

THE RADIATION LABORATORY OF THE JOHNS HOPKINS UNIVERSITY HAS POSITIONS FOR PHYSICISTS AND ENGINEERS IN THE FIELDS OF:

- *ELECTRONIC CIRCUITS*
- *MICROWAVES*
- *SYSTEMS AND SERVO ANALYSIS*
- *STATISTICAL COMMUNICATION THEORY*

THIS UNIVERSITY LABORATORY OFFERS A VARIETY OF CHALLENGING PROBLEMS AT BOTH JUNIOR AND SENIOR LEVELS. A POSITION HERE MEANS:

- Favorable Arrangements for Advanced Study in the Graduate Schools
- Faculty Rank and Privileges for Senior Staff
- One Month Paid Vacation
- Excellent Laboratory Facilities Located Near the University Campus
- Good Growth and Promotional Possibilities

RADIATION LABORATORY
THE JOHNS HOPKINS UNIVERSITY
HOMEWOOD CAMPUS BALTIMORE 18, MD.

The FUTURE is in Florida

The South, and Florida in particular, has risen to a new status in the engineering and manufacturing fields. Many industries, old and new, have located here in line with decentralization policy and to take advantage of the many potentialities of the area. Lower living costs, low taxes, and year 'round outdoor life appeal to both labor and management.

Engineering firms, especially, find Florida an ideal location in which to conduct operations. As an index to the growth of the electronic industry in the state, the number of IRE members in Florida has increased over 300% in the last three years. There is no doubt that the future is in Florida.

RADIATION, INC. is one of many engineering firms to locate in Florida. Engaged in electronic research and development, our work includes the fields of avionics, nucleonics, and automation.

Our engineers enjoy the low living costs and pleasant living conditions of the area plus the opportunities offered by a progressive, expanding organization.

Qualified engineers with experience in electronic circuit design, aircraft instrumentation, and stress analysis are invited to contact R. L. Bickford, Director of Personnel, RADIATION INC., P.O. Drawer Q, Melbourne, Florida.

RADIATION Inc. Melbourne, Fla.
Orlando, Fla.
Electronic RESEARCH · DEVELOPMENT · PRODUCTION

Full Steam Ahead

ELECTRONICS ENG.
PHYSICISTS
MECHANICAL ENG.

with BENDIX RADIO

It's full steam ahead at Bendix Radio . . . More work to be done! More experienced engineers needed! More interesting, challenging positions to be filled! Your future is bright when you join the efficient Bendix Radio team!

Challenging work in The development of:

Radar (Airborne and Ground)
Auto Radio and Test Equip.
Airborne & Mobile Comm. Equip.
Missile Guidance Systems
Computer Applications
Research & Development
(Incl. Transistors and Printed Circuitry)

Excellent salaries.
Semi-annual work reviews with advancement on merit.
Modern, air-conditioned plant located in beautiful suburban area with ample housing, good schools, attractive shopping centers, major league sports.
Numerous employee benefits.

Call, wire or write Mr. L. H. Noggle, Dept. M

Bendix Radio
DIVISION OF BENDIX AVIATION CORP.
BALTIMORE 4, MD. VAlley 3-2200

Transformer Engineers—
COLLINS RADIO COMPANY

has openings in Dallas, Texas, for qualified electronic engineers experienced in design and development of radio transformers and components.

Applicants must have B.S. in Electrical Engineering, Electronics, or Physics, and at least two years experience in magnetics or electro-magnetics including high permeability steel applications.

Employee benefits include air conditioned plant, free insurance, liberal vacations, and company-paid retirement benefit plan.

Qualified applicants write giving educational and experience resume to:

JOHN D. MITCHELL
Dir. of Industrial Engineering
Collins Radio Company
Texas Division
1930 Hi-Line Drive, Dallas 2, Texas

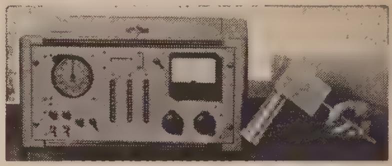
News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

(Continued from page 123A)

Nuclear Instrumentation

This unit manufactured by **Radiation Instrument Development Laboratory,** 2337 W. 67 St., Chicago 36, Ill., is equipped with a Veeder Root Register, Standard Electric timer and will accommodate anthracene, sodium iodide, and other crystals, including thermal neutron.



It has a direct-coupled amplifier with a gain of 2,500 which overloads without overshoots.

The stability factor is greater than 100.

Output of the amplifier feeds a discriminator so that the unit may be used as an integral-type pulse height analyzer.

The descriminator control is a ten-turn Helipot for accurate settings.

The high voltage range is negative, 500 to 1,500 volts using precision wire-wound resistors.

Depressed zero scale. High voltage regulation is better than 0.005 for 1 per cent change in line voltage.

(Continued on page 127A)

MICROWAVE ENGINEER OR PHYSICIST

For theoretical development of wave propagation in the region of dielectric and metallic boundaries, including methods of approximation in boundary value problems, investigation of propagation through ferrites, development of specialized microwave components and application to systems. Complete digital and analogue computing facilities are available. Applicant must also be capable of directing an experimental program for verification of theoretical predictions.

MICROWAVE ENGINEER

To conduct basic experiments on microwave circuits and transmission through dielectric media, and to aid in the design of basic test equipment involving novel principles. A good understanding of electromagnetic wave phenomena is essential. Recent graduates with outstanding records will be considered.

Please send resume to:

Salary Personnel
Goodyear Aircraft Corp.
Akron 15, Ohio

News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

(Continued from page 126A)

Capacitor Catalog

Five new and revised catalog sheets covering special types of ceramic capacitors are now available from **Centralab, Div. of Globe-Union Inc.,** 900 E. Keefe Ave. Milwaukee, Wis. Complete technical specifications are given for the following styles: BC disc capacitors, single and dual ceramic discs 470 μμf to 0.02 μf, 500 volts dc working. Write for Technical Bulletin 42-4R.

Ceramic Trimmers, five construction types in single and multiple section design. Capacity ranges from 1–3.5 μμf. to 225–400 μμf. Zero and negative temperature coefficients. Comply with JAN-C-81 specifications for military use. Write for Technical Bulletin 42-101R;

Tubular Trimmer, single and dual types, plus a 1 μf terminal style. Write for Technical Bulletin 42-59R;

Feed-through capacitors, bushing mounted tubular style capacitors for all high frequency applications. Now available in 500, 1000, and 1500 vdcw styles, these units range from 10 μμf to 6500 μμf capacities. Write for Technical Bulletin 42-206.

(Continued on page 138A)

TUNG-SOL 50 YEARS 1904 1954 ACHIEVEMENT

ENGINEERS

Have you developed a "Success Perspective"?

If a year or two of practical experience has given you the youthful maturity that demands more than just a job, you may be interested in our "career opportunities" in color TV, crystal products and electronic tubes.

Submit resume or address request for personal interview to D. Bellat, Personnel Director.

TUNG-SOL ELECTRIC INC.
200 Bloomfield Avenue
Bloomfield, N.J.

SPECIAL OPPORTUNITIES FOR

SENIOR ENGINEERS

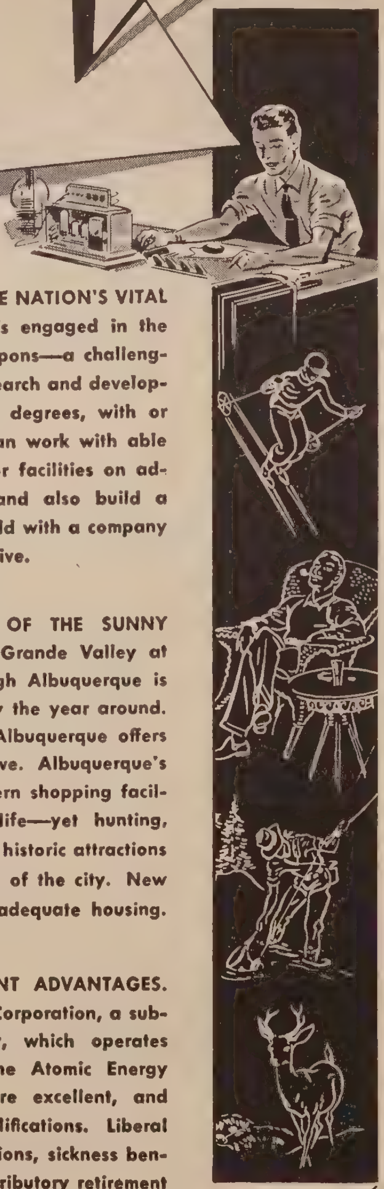
Convair in beautiful, sunshiny San Diego invites you to join an "engineers" engineering department. Interesting, challenging, essential long-range projects in commercial aircraft, military aircraft, missiles, engineering research and electronics development. Positions open in these specialized fields:

Electrical Design | **Servo-mechanisms**
Mechanical Design | **Aerodynamics**
Structural Design | **Thermodynamics**
Structures | **Operation Analysis**
Weights | **System Analysis**

Generous travel allowances to those accepted.
For free brochure, write Mr. H. T Brooks,
Engineering Dept. 800

CONVAIR
IN BEAUTIFUL
SAN DIEGO
3302 PACIFIC HIWAY
SAN DIEGO 12, CALIFORNIA

- MECHANICAL ENGINEERS
- ELECTRONICS ENGINEERS
- ELECTRICAL ENGINEERS
- X-RAY ENGINEER
- PHYSICISTS
- AERODYNAMICISTS
- MATHEMATICIANS



WORK ON THE FRONT LINE OF THE NATION'S VITAL DEFENSE PROGRAM. Sandia Corporation is engaged in the development and production of atomic weapons—a challenging new field that offers opportunities in research and development to men with Bachelor's or advanced degrees, with or without applicable experience. Here you can work with able colleagues, eminent consultants and superior facilities on advanced projects of high importance — and also build a permanent career in a rapidly expanding field with a company that recognizes individual ability and initiative.

LIVE IN ALBUQUERQUE, THE HEART OF THE SUNNY SOUTHWEST. Located in the historic Rio Grande Valley at the foot of the Sandia Mountains, mile-high Albuquerque is famous for its climate—mild, dry and sunny the year around. A modern, cosmopolitan city of 150,000, Albuquerque offers unique advantages as a place in which to live. Albuquerque's schools, churches, theaters, parks, and modern shopping facilities afford advantages of metropolitan life—yet hunting, fishing, skiing and a multitude of scenic and historic attractions may all be found within a few hours' drive of the city. New residents have little difficulty in obtaining adequate housing.

ENJOY THESE OTHER IMPORTANT ADVANTAGES. These are permanent positions with Sandia Corporation, a subsidiary of the Western Electric Company, which operates Sandia Laboratory under contract with the Atomic Energy Commission. Working conditions are excellent, and salaries are commensurate with qualifications. Liberal employee benefits include paid vacations, sickness benefits, group life insurance, and a contributory retirement plan. This is not a Civil Service appointment.

Make Application to:

PROFESSIONAL EMPLOYMENT
DIVISION A

SANDIA
Corporation

SANDIA BASE • ALBUQUERQUE, NEW MEXICO

30,000 Member Engineers find IRE DIRECTORY is
5 Ways Faster!

1. It shows all the radio-electronic products a firm makes, by code numbers after its alphabetical listing.

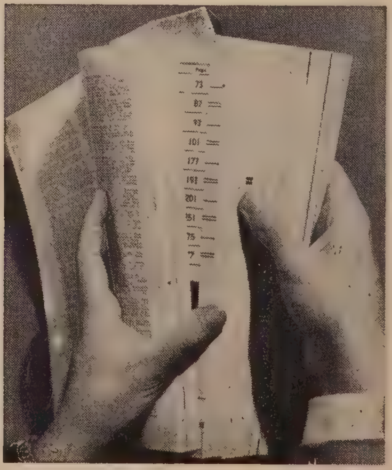
2. It groups products into ten directories of related engineering interest. It does not mix meters with motors, or components with test instruments because of names that are alike.

3. It indexes all products into 100 basic classes, cutting duplication and gaining speed by brevity.

4. Yet, it provides plenty of detailed product identification through over 500 sub-classes by a concise number system which avoids confusing repetition.

5. The Machol Thumb Index System (picture below) gives dictionary-like convenience in speedy finding of 100 product groups.

A few minutes study of the IRE DIRECTORY method will repay you well in saved time and easy use. Get the most out of your IRE DIRECTORY.



Held over from March because of lack of space

STUDENT BRANCH MEETINGS

ALABAMA POLYTECHNIC INSTITUTE IRE BRANCH

Election of Officers; January 11, 1954.

UNIVERSITY OF ARIZONA IRE-AIEE BRANCH

"The Electrical Engineer and Atomic Energy" by Mr. McLenegan, Hartford Plant in Washington; December 7, 1953.

CALIFORNIA INSTITUTE OF TECHNOLOGY IRE BRANCH

"Industrial Uses of Atomic Energy" by Richard B. Barton, General Electric Co.; January 11, 1954.

UNIVERSITY OF COLORADO IRE-AIEE BRANCH

"The Organization and Benefits of the National AIEE" by W. C. DuVall, Faculty, University of Colorado and Films, Alcoa's "Wiring with Aluminum" and General Electric's Naturally it is F.M." and "Research Makes the Difference"; October 28, 1953.

"Hi-Fi Systems" by Richard Keller, Student, University of Colorado; November 11, 1953.

Description and tour of the new installation at Mountain States Telephone and Telegraph new dial exchange building; November 16, 1953.

"Travels in Japan" by Dr. W. W. Lewis, formerly with General Electric; December 8, 1953.

COLUMBIA UNIVERSITY IRE-AIEE BRANCH

"Analogue Computers" by Prof. W. Easterling, graduate faculty; November 18, 1953.

"The Application of Transistors" by Mr. R. Lambert, graduate faculty; December 16, 1953.

Talk on "Magnetic Amplifiers" by Prof. W. LaPierre based on a paper by W. C. Johnson of Princeton; January 7, 1954.

UNIVERSITY OF DELAWARE IRE-AIEE BRANCH

"The Place of the Public Utility Industry in our Expanding Economy" by W. C. Astley, Philadelphia Electric Co.; November 20, 1953.

"High Fidelity" by F. McIntosh, President, McIntosh Laboratory, Inc.; December 7, 1953.

UNIVERSITY OF DENVER IRE-AIEE BRANCH

General Meeting; January 11, 1954.

FENN COLLEGE IRE BRANCH

"Ultrasonics" by Dr. Mattiat, Brush Development Co.; January 14, 1954.

GEORGE WASHINGTON UNIVERSITY IRE BRANCH

"Professional Development of the Graduate Engineer" by Dr. Ralph D. Bennett, Naval Ordnance Lab.; January 6, 1954.

UNIVERSITY OF ILLINOIS IRE-AIEE BRANCH

"Servomechanisms" by C. D. Burdick, Sperry Gyroscope Co.; October 14, 1953.

"Electrical Engineering in Industry" by Mr. See, General Electric Co.; November 5, 1953.

"Colored Television" by Mr. C. N. Hoyler, Head of RCA Research Labs.; November 10, 1953.

"The Micro-switch and its Uses" by Mr. Richie, President of Micro-Switch Corp.; December 1, 1953.

"Portable Radio Communications" by Mr. Wiess, Motorola Corp.; December 17, 1953.

STATE UNIVERSITY OF IOWA IRE BRANCH

"High Fidelity Sound" by John V. Wait, Student, State University of Iowa; January 6, 1954.

"Plastics as Materials of Construction" by Dr. W. M. Brunar, E. I. DuPont deNemours and Co. Inc.; January 13, 1954.

(Continued on page 130A)

Complete machine shop for model building
Finest Electronic Equipment
Work includes new circuits and systems

LEADERS and SPECIALISTS in ENGINEERING offered splendid opportunities in Boston Engineering Laboratory!

Men qualified to handle high level assignments in electronics are offered a challenging opportunity in Boston, under ideal working conditions divorced from production. The laboratory provides stimulating projects, an atmosphere of scientific progress and provides assistance towards your personal advancement or professional recognition. You will work with a top level technical staff possessing the finest facilities. Administrative positions are open to men qualified to guide the efforts of others.

MICROWAVE ENGINEERS

Senior engineers to handle design and development projects and provide technical direction of other top-level engineers working on microwave circuits and microwave plumbing in the development of military airborne electronic equipment. Should have 5 years' experience in such work and at least a BS degree.

ELECTROMECHANICAL ENGINEERS

Senior engineers to direct groups of top level engineers working on mechanical designs of airborne electronic equipment. Should be able to estimate operating and development expenses to judge and coordinate staff work. Should have 5 years' experience in the field and at least a BS degree.

ELECTRONIC Engineer-in-Charge

To plan, direct and control the activities of engineers engaged in design and development of large, complex electronic equipment. Must have at least 5 years' experience in military electronic equipment and be familiar with latest techniques used in airborne electronic methods. Must have at least a BS degree.

ENGINEERING SPECIALIST (Weight Control)

Experienced in the mechanical design of airborne electronic equipment. Should have a BS degree and approximately 5 years' experience in aircraft weight control and high strength-to-weight ratio structures. Should be qualified to direct the work of a group of engineers.

RADAR SYSTEMS AND CIRCUIT ENGINEER

To assume responsibility for electronic circuit design for major elements of complex airborne electronic equipment. Should have a BS degree and about 5 years' experience.

Sylvania provides financial support for advanced education as well as a liberal insurance, pension and medical program. Investigate a career with Sylvania.

INTERVIEWS BY APPOINTMENT
Don Bradley, Personnel Manager
Boston Engineering Laboratory

SYLVANIA
ELECTRIC PRODUCTS INC.
70 Forsyth Street • Boston, Massachusetts • KEnmore 6-8900

ARCTIC COLD
or
TROPIC HEAT
Supremacy Quality

In every corner of the globe . . . Standard Piezo Crystals are functioning with complete fidelity . . . just as faithfully as they did in their final, comprehensive inspection in our plant. Standard Piezo Crystals are truly masterpieces of precision . . . the rugged, *accurate* and *dependable* end-product of an exacting and vigorous system of manufacture, inspection and quality control. Quality is *standard* with Standard Piezo.

Let our engineers help you with your Crystal needs. Send specifications or an outline of your requirements.

Standard Piezo Co.
CARLISLE PENNSYLVANIA
Phone 1495

There is Always One Leader in Every Field

BODNAR INDUSTRIES, Inc.

leads in the field of

TRANSILLUMINATED PLASTIC LIGHTING PLATES

BECAUSE OF *Quality* • *Uniformity* • *Performance*
Design & Layout "Know-How Service"
Quantity Production Promptly

NEW YORK —19 Railroad Ave., New Rochelle (Home Office)
TEXAS —208 West Avery, P.O. Box 4116, Station A, Dallas
CALIFORNIA—4440 Lankershim Blvd., P.O. Box 264, North Hollywood
CANADA —313 Montreal Trust Bldg., 67 Yonge St., Toronto

SPECIMEN PANEL MIL-P-7788 (AN-P-89) SENT ON LETTERHEAD REQUEST

Hermetic Seal Products Co.

29 South Sixth Street
Newark 7, New Jersey

FIRST AND FOREMOST IN MINIATURIZATION

MEMBERSHIP

(Continued from page 108A)

Raiti, J. J., 1015 Virginia Ave., New York 72, N. Y.
Rawson, M. D., 905 S. Normandie, Los Angeles, Calif.
Ray, S. R., 3148 Westover Dr., S.E., Washington 20, D. C.
Reale, E. P., 49 Corby Ave., Toronto, Ont., Canada
Reber, P. W., 669 Ninth St., Hammonton, N. J.
Remaley, C. W., 158 Pennystone Ave., San Antonio 10, Tex.
Rhoads, A. S., Jr., 80-63—268 St., Floral Park, L. I., N. Y.
Rhoads, D. O., 7110 Eastlawn Dr., Cincinnati 37, Ohio
Riggs, J. O., 601 W. Water, Elmira, N. Y.
Ritter, V. H., R.F.D. 2, Clyde, N. Y.
Roche, T. F., The Roflan Co., R.F.D. 1, Topsfield, Mass.
Roe, E. O., 3805 E. Independence, Tulsa, Okla.
Roode, R. J., 531 Park Overlook Dr., Worthington, Ohio
Ropar, J. M., 306 Martin Ave., Pittsburgh 16, Pa.
Roth, S., 5632 Waverly St., Montreal 14, Que., Canada
Rowland, L., Aura Manufacturing Co., Inc., 119 Chestnut St., New Haven, Conn.
Rubega, R., 101 Riverview Ave., New London, Conn.
Rudroff, M. G., 3670 Cornell Blvd., Winston-Salem, N. C.
Sachs, H. S., 6 Bryson Rd., Fair Lawn, N. J.
Sample, D. R., Box 1166, Victorville, Calif.
Sanfield, W., 942 Harbor St., Conneaut, Ohio
Santa Ana, L. T., 1020 Marlow St., El Paso, Tex.
Sauer, G., 41 Manetto Dr., Plainview, Hicksville, L. I., N. Y.
Savage, K. D., 6521 Corbin Ave., Houston 24, Tex.
Savet, P. H., 361 Merrifield Ave., Oceanside, L. I., N. Y.
Schatz, R. A., Westinghouse Electric Corp., 469 Sharpsville, Sharon, Pa.
Schleicher, H. M., The American Metal Co., Ltd., 61 Broadway, New York, N. Y.
Schley, L. L., 22 Madison Rd., Wellesley Hills, Mass.
Schnuck, R. Q., Rm. 1701, 1365 Cass Ave., Detroit 26, Mich.
Shefter, S., 3121 Arthur St., Belmar, N. J.
Shew, W. W., 144 Cedarbrook Rd., Merion Golf Manor, Ardmore, Pa.
Shimshoni, M. E., Jerusalem St., Haifa, Israel
Shomer, J. E., 50 Mullens La., Bernardsville, N. J.
Shoob, J. P., 121 Race St., Sunbury, Pa.
Sicuranza, A. J., Jr., 107-22—105 St., Ozone Park 16, L. I., N. Y.
Simsen, C. A., 323 Bernard St., Richland, Wash.
Sizuki, E., 907 W. Fletcher St., Chicago, Ill.
Slaker, F. A., 1755 East 33 St., Brooklyn 34, N. Y.
Small, H. E., Crown Point Rd., Thorofare, N. J.
Smith, J. B., 4401 Neville Rd., Cleveland 21, Ohio
Smith, K. W., 1436 Homestead St., Baltimore 18, Md.
Smoliar, G. D., 2248 East 65 St., Brooklyn 34, N. Y.
Snyder, V. A., 7 Hyatt St., Staten Island 1, N. Y.
Sokolov, J., 208 Babylon Tpk., Freeport, L. I., N. Y.
Somers, H., 68 St. Cyrille, Quebec City, Que., Canada
Sommers, D. J., R.F.D. 1, Brookline, N. H.
Sparks, R. S., 507 Mascoutah Ave., Belleville, Ill.
Stansberry, C. L., 12605 Goodhill Rd., Wheaton, Md.
Stedman, J. D., 1714 Locust St., Kansas City 7, Mo.
Stern, M. A., J.Y.M. & W.A., Rochester 1, N. Y.
Stern, S., 63 Thimbleberry La., Levittown, Pa.
Stoddard, J. E., Gage Research Laboratory, Pratt & Whitney Co., Charter Oak Blvd., West Hartford, Conn.
Storer, J. E., 13 Cutler Farm Rd., Lexington 73, Mass.

(Continued on page 134A)

Uniformity

—batch to batch uniformity that makes inspection unnecessary

> *We have used every type of GA&F Carbonyl Iron Powder thus far produced. The overall quality and batch-to-batch uniformity of your products have always been gratifying to us. Because of this product dependability, we feel that incoming inspection of your powders is unnecessary.*
>
> Richard D. Poneman
>
> **President**
> **Pyroferric Company, Inc.**
> **621 East 216th Street**
> **New York 67, N. Y.**

G A & F Carbonyl Iron Powders are used to produce cores for transformer and inductor coils—to increase Q values, to vary coil inductances, to reduce the size of coils, to confine stray fields and to increase transformer coupling factors.

These powders are microscopic, almost perfect spheres of extremely pure iron. They are today produced in eight carefully controlled types, ranging in average particle-size from three to twenty microns in diameter. The Carbonyl Process assures the quality and uniformity of each type.

We urge you to ask your core maker, your coil winder, your industrial designer, how G A & F Carbonyl Iron Powders can increase the efficiency and performance of the equipment or product you make, while reducing both the cost and the weight. We also invite inquiries for powders whose performance characteristics are different from those exhibited by any of our existing types.

GA&F
carbonyl iron powders
ANTARA CHEMICALS

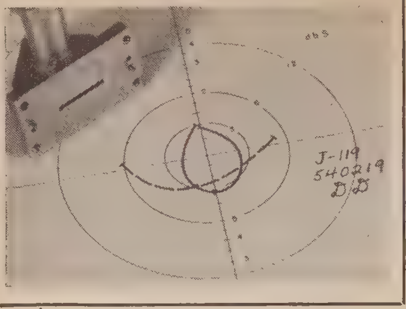
This 32-page book offers you the most comprehensive treatment yet given to the characteristics and applications of G A & F Carbonyl Iron Powders. 80% of the story is told with photomicrographs, diagrams, performance charts and tables. For your copy—without obligation—kindly address Department 77.

GA&F® CARBONYL IRON POWDERS

ANTARA. ANTARA CHEMICALS

A SALES DIVISION OF GENERAL ANILINE & FILM CORPORATION
gaf 435 HUDSON STREET • NEW YORK 14, N. Y.

MEMBER mpa METAL POWDER ASSOCIATION



MICROWAVE DEVELOPMENTS

Wheeler Laboratories is an engineering organization offering consulting and engineering services in the fields of radio and radar.

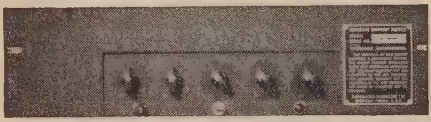
In designing microwave components, impedance plots on circle charts of reflection coefficient are our constant guide in understanding and making best use of waveguide circuits such as the resonant iris shown above.

At present, Wheeler Laboratories includes a staff of twenty engineers under the personal direction of Harold A. Wheeler, a group of designers, and a model shop. Regular additions to the staff are continuing in order to keep pace with our expanding program of work.

Inquiries are welcomed regarding specialized problems in microwave design; a brief summary of our work is available on request.

Wheeler Laboratories, Inc.

122 Cutter Mill Road, Great Neck, N.Y.
HUnter 2-7876



RACK MOUNTING MODELS
105-125 V. 60C INPUT
OUTPUT CURRENT MAY BE SET AT ANY VALUE FROM 0.2 TO 50 M.A. D.C. AS LOAD VOLTAGE VARIES BETWEEN 0-150 V. MODEL 1A-R IS CONSTANT WITHIN 1%, MODEL 1B-R WITHIN 0.1%.
IMMEDIATE DELIVERY
MODEL 1A-R $149—MODEL 1B-R $245
0.2-100 M.A. RANGE $13 MORE
Other models to specifications

ELECTRONICALLY REGULATED
D.C. CONSTANT CURRENT POWER SUPPLIES
OUTPUT CURRENT IS HELD CONSTANT AS LOAD VARIES

OTHER MODELS AVAILABLE
WRITE DEPT. 101 FOR LITERATURE
ASSOCIATED SPECIALTIES CO.
1751 MAIN STREET
OREFIELD, PENNSYLVANIA

AN/APR-4 LABORATORY RECEIVERS

Complete with all five Tuning Units, covering the range 38 to 4,000 Mc.; wideband discone and other antennas, wavetraps, mobile accessories, 100 page technical manual, etc. Versatile, accurate, compact—the aristocrat of lab receivers in this range. Write for data sheet and quotations.

We have a large variety of other hard-to-get equipment, including microwave, aircraft, communications, radar; and laboratory electronics of all kinds. Quality standards maintained. Get our quotations!

SPECIAL TUBE BARGAINS: 723A/B $10.00; 2K25 $15.00; 417A $8.00; QK-60, QK-61 Tuneable CW Package Magnetrons (2800-3025, 2975-3200mc) $50.00; 3C 22 $65.00; 446A, 10 for $8.50; 6AK5, 10 for $7.50.

ENGINEERING ASSOCIATES
434 PATTERSON ROAD DAYTON 9, OHIO

MEMBERSHIP

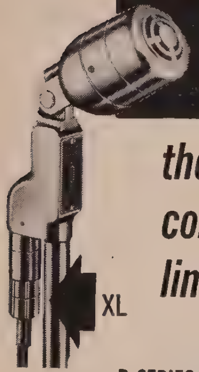
(Continued from page 132A)

Stuart, R. W., General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Suiters, C. W., 92 Overbrook Rd., West Hartford, Conn.
Sullivan, P. A., 15 Rumford Rd., West Roxbury, Mass.
Swoffer, D. R., 406 S. Second St., Clearfield, Pa.
Tannenbaum, D. A., 1025 Collings Ave., West Collingswood, N. J.
Templeman, L. I., Radio Receptor Co., Inc., 240 Wythe Ave., Brooklyn, N. Y.
Thayer, R. W., R.F.D. 1, Rosendale Rd., Schenectady, N. Y.
Theisinger, L. P., 5-A Oak Grove Dr., Baltimore 20, Md.
Thielen, L. R., 21 Waldron Ave., Summit, N. J.
Thivierge, R. D., 8377 Des Belges, Montreal, Que., Canada
Thomas, R. G., 3716 N. Springfield Ave., Skokie, Ill.
Tillman, J. T., Jr., 2308 Lodi St., Syracuse, N. Y.
Toth, G. L., 207 Shoshone St., Buffalo 14, N. Y.
Trachtenberg, J. M., 2426—64 St., Brooklyn 4, N. Y.
Turner, R. E., 1712 Hilton Rd., Burlington, N. C.
Twinam, J. R., 132 Levis Dr., Mt. Holly, N. J.
Umbel, F. K., Pittsburgh Plate Glass Co., Creighton, Pa.
Urbanski, L. J., 1933 AACS Sqdn., c/o Postmaster, New York, N. Y.
Valliere, E. G., 4704 Chestnut St., Apt. 10, Philadelphia 39, Pa.
Vance, V. G., Pawling Manor, Staatsburg, N. Y.
Van Sutphin, B., 4019—33 St., Mt. Rainier, Md.
Vaillancourt, R. M., 7 Sainte-Marie, Levis, Que., Canada
Vincent, R. M., 9 Shawnee Gardens, Tuckahoe 7, N. Y.
Volz, H., Jr., 444 S. Tenth St., Saginaw, Mich.
Vonderschmitt, B. V., 129 Colwick Rd., Merchantville, N. J.
Vuchetich, J. B., 4030 S. Rockwell St., Chicago 32, Ill.
Wahlstrom, G., 903 Pine St., San Francisco 2, Calif.
Wallace, H. L., Parkway Apts., Apt. 34-C, Haddonfield, N. J.
Wallen, A. C., 65 Prestwick Dr., Youngstown 12, Ohio
Warren, J. R., 92 Brattle St., Cambridge 38, Mass.
Watson, W. J., 28-A Lakeview Ave., Leonia, N. J.
Weaver, C. E., 292 Elkwood Ave., New Providence, N. J.
Weidner, D. M., 626 Goucher St., Johnstown, Pa.
Weill, R. L., Skydyne, Inc., River Rd., Port Jervis, N. Y.
Weiss, S., 6503 N. Uber St., Philadelphia 38, Pa.
Welling, E. A., Suite 201, 10317—107 Ave., Edmonton, Alta., Canada
Weiner, F., 125-02—111 Ave., South Ozone Park, L. I., N. Y.
Weier, J. B., 1335 S. Peoria, Apt. B-45, Tulsa, Okla.
Wescoat, W. L., 110 Oakwood Dr., Packanack Lake, N. J.
Whitaker, R. O., 914 Fourth Ave., Silvis, Ill.
Whitman, C. L., Borton Landing Rd., Moorestown, N. J.
Whitmeyer, L. J., Jr., Box 357X, R.F.D. 1, Beaumont, Tex.
Wholey, L. T., 33 Starbird St., Lowell, Mass.
Wilson, J. E., Hazeltine Corp., 58-25 Little Neck Pkwy., Little Neck, L. I., N. Y.
Windsow, R. T., Box 468, Edinboro, Pa.
Wisner, H. L., 5418 Rosslyn Ave., Indianapolis 20, Ind.
Worden, O. L., Box 991, Alfred, N. Y.
Wotton, R. C., 615 West 164 St., Apt. D-43, New York 32, N. Y.
Yanick, S. J., Holloman Air Force Base, Holloman, N. Mex.

(Continued on page 136A)

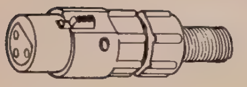
what a great difference Cannon quality makes!

CANNON PLUGS



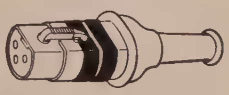
the most complete audio lines

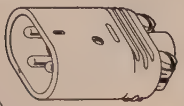
P SERIES

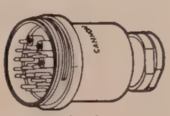

XL SERIES

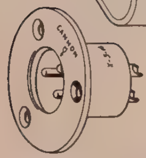
In addition to the lines illustrated, the 45E Test Point Jacks and connectors in the GB, U, and M1-4 and selections from AN, K and RK series are available through Cannon Electric distributors. Other electronic-electric distributors also sell certain items in the Cannon line, including XL, M1-4, and GB series connectors, and a variety of Cannon Specialty Lights. Write for the RJC and Audio Connector Bulletins.

D SERIES


UA SERIES


O SERIES


K (TV) SERIES


X SERIES

CANNON ELECTRIC

Since 1915

Refer to Dept. 377

CANNON ELECTRIC COMPANY, 3209 Humboldt St., Los Angeles, Calif. • Factories in Los Angeles; East Haven; Toronto, Canada; London, Eng. Representatives and distributors in all principal cities.

CANNON ELECTRIC

Output from this rugged Genisco Accelerometer

(GLH MODELS)

is measured in volts ...not millivolts!

minimizes need for amplifying devices!

123
Genisco
INCORPORATED
2233 Federal Ave.
Los Angeles 64, California
DWG.
SER.
RANGE

IMPORTANT GLH PERFORMANCE CHARACTERISTICS

Damping Factor: Instruments up to ±7.5 G's inclusive can be damped .4 to .6 critical; ±7.5 G's to ±10 G incl. .35 to .55 critical; above 10 G's .3 to .5 critical.

Range: ±2 G's to ±30 G's; zero acceleration at midpoint.

Natural Frequencies: 6 to 23 cps. (depending upon range).

Potentiometer Resistance: From 1000 to 10,000.

Resolution: Normally from .25 to .3%, depending upon resistance requirements.

Steady State Acceleration: Can withstand 75 G's in all planes without damage; somewhat less along sensitive axis in low range units.

Linearity: ±0.5% of best straight line through calibration points.

Resistance to shock: 40 G's in any lateral direction; shock loads in 2 directions, equal to range, without damage.

Crosstalk error: Less than 1% change caused by lateral acceleration equivalent to total range of instrument.

Weight: 2 to 2¼ lbs., depending on "G" range.

Overall Physical Size: 3¼"x3⅛"x 2⅝".

Static Friction: .075 G max. up to and including ±7.5 G's.

0.5% full scale output above ±7.5 G's.

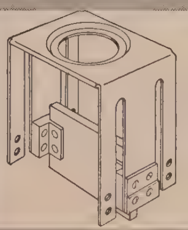
(special modifications for higher natural frequencies and greater damping can be supplied.)

A precision built potentiometer is the secret behind the high output of Genisco's GLH Accelerometer

As much as 50 volts can be put across the potentiometer of the standard GLH, and up to 72 volts on special models. Since the wiper scans the full voltage range, use of the GLH eliminates the need for amplifying devices in many guided missile control and flight test applications.

Keeping the resistance winding free from foreign materials during assembly, careful adjustment of the wiper pressure to precise tolerances, and hermetic sealing of the instrument in inert gas result in electrical output noise so low it can be considered negligible—over a life span in excess of 4 million cycles.

Complete specifications and prices on the GLH are available from Genisco, Inc., 2233 Federal Ave., Los Angeles 64, California. Write today.


A parallelogram suspension confines the mass of the GLH to a virtual straight line motion and provides excellent lateral rigidity.

Genisco
INCORPORATED

Other accelerometer models also available!

Write today for information on Genisco's new GMO miniature potentiometer-type accelerometer (weighs only 7 ounces), the new tapped-potentiometer-type accelerometers, and the new DDL Dual-Damped (oil and magnet) accelerometers. Prompt deliveries on all models.

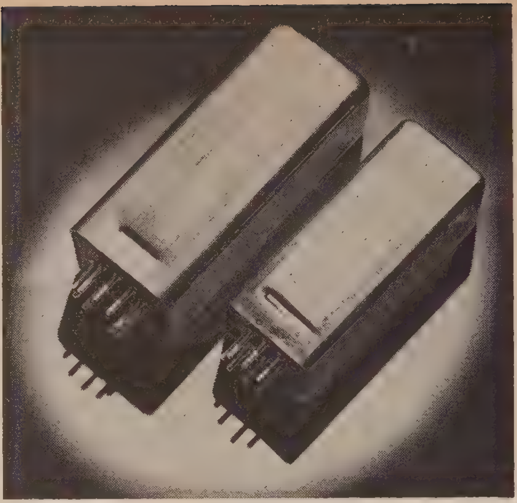
LEE-PAC

PLUG-IN
TRANSISTOR
CIRCUITS

COMPLETE
SELF
CONTAINED
STAGES

series now available include:

OSCILLATORS
AMPLIFIERS
MULTIVIBRATORS
PULSESHAPERS



The most versatile units ever made. A plug-in system of circuits that can be used for any application. The LEE-PAC circuits are separate stages inclosed in a metal case with standard seven and nine pin bases.

Write today for complete data.

LEE LABORATORIES, Inc.
Genesee, Pennsylvania

IT'S
HARVEY
FOR PROMPT
"OFF-THE-SHELF" DELIVERY

Whether it's equipment, components or other electronic requirements, you will always find them in Harvey's extensive stocks, ready for immediate delivery to you anywhere.

WRITE
PHONE
or WIRE

Harvey's twenty-five years of service to the industry are your assurance of understanding 'know-how' and complete dependability.

hrc

Telephone
JUdson 2-1500

HARVEY
RADIO COMPANY, INC.
103 West 43rd St., New York 36, N. Y.

MEMBERSHIP

(Continued from page 134A)

Zeigler, K. I., 330 West 42 St., McGraw-Hill Book Co., New York, N. Y.
Zemel, I., 2265 Strauss St., Brooklyn 12, N. Y.
Zimmerman, F. M., 8857 Burton Way, Los Angeles, Calif.
Zitkus, A. J., 1822 S. Ruble St., Chicago 16, Ill.
Zivitofsky, F. I., 630 Dumont Ave., Brooklyn 7, N. Y.
Zuehl, W. R., 929 Jefferson Ave., Sequin, Tex.

The following transfers and admissions were approved to be effective as of March 1, 1954:

Transfer to Senior Member

Abfalter, H. F., 226 S. Chestnut St., Arlington Heights, Ill.
Berge, R. G., 154 Saville Rd., Mineola, L. I., N. Y.
Brown, E. M., 600 Brookside Ave., Roosevelt, L. I., N. Y.
Challenner, A. P., University of Oklahoma, Norman, Okla.
Doane, J. E., 6358—31 St., N.W., Washington 15, D. C.
Doba, S., Jr., Bell Telephone Laboratories, Murray Hill, N. J.
Downes, L. C., 5103 Chesley Ave., Los Angeles 43, Calif.
Early, J. M., 114 Franklin St., Morristown, N. J.
Fairstein, E., 100 Ontario La., Oak Ridge, Tenn.
Farrar, C. L., University of Oklahoma, Norman, Okla.
Gough, L. E., Lincoln Highway East, R.F.D. 12, Fort Wayne 8, Ind.
Hall, J. R., 446 Pleasant St., South Weymouth 90, Mass.
Huckaby, J. H., 4169 Schwinn Dr., Dayton 4, Ohio
Hughes, F. J., 99 Cord La., Levittown, L. I., N. Y.
Leonard, S. C., Richmond, Cheshire, Mass.
Macdonald, J. R., Texas Instruments, Inc., 6000 Lemmon Ave., Dallas 9, Tex.
Mandel, P., LaRadio-Industrie, 55–59 Rue des Orteaux, Paris, France
Meisling, T., Electrical Engineering Division, University of California, Berkeley 4, Calif.
Nathan, R., 1841 Bluefield Pl., Cincinnati 37, Ohio
Pike, B. W., 606-A Essex Cir., China Lake, Calif.
Roberts, R. S., 136 Cherrydown Ave., London E. 4, England
Rohloff, H. E., 227 Church St., New Haven 6, Conn.
Schmidt, L. M., 20 Priscilla La., Poughkeepsie, N. Y.
Schrader, G. F., 1636 N.W. Seventh Ave., Gainesville, Fla.
Smith, H. F., 1919 Berkley Ave., Dallas, Tex.
Stolze, W. J., Stromberg-Carlson Co., 100 Carlson Rd., Rochester, N. Y.
Susskind, C., Microwave Laboratory, Stanford University, Stanford, Calif.
Taylor, G. O., 5244 Arrow Rd., Cincinnati 11, Ohio
Tuma, G., School of Electrical Engineering, University of Oklahoma, Norman, Okla.
Waxler, D., Box 135, Stittville, N. Y.
Wimpy, E. K., 198 Low St., Newburyport, Mass.
Woodward, C. P., 318 Temple Blvd., Palmyra, N. J.
Zarky, B., 8649 Keeler Ave., Skokie, Ill.

Admission to Senior Member

Anderson, D. J., 4602 Merivale Rd., Chevy Chase, Md.
Burwell, A. C., Jr., Sylvania Electric Products, Inc., Emporium, Pa.
Candido, J. V., Dir-Eng AACS Globecomm Hdqtrs., Bldg. T-1-8, Andrews Air Force Base, Washington 25, D. C.
Chernish, G., 1993 Coholan St., Niagara Falls, Ont., Canada

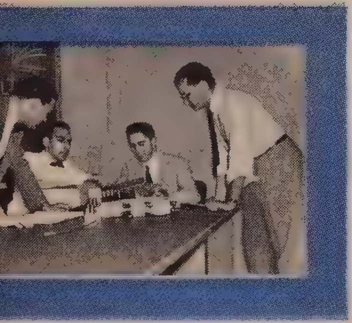
(Continued on page 140A)

COMPRESSING TIME

In any security program *time* is the one irreplaceable element. Making the most of time is particularly vital in guided missiles projects. Fairchild's Guided Missiles Division has demonstrated its ability to "spend" time effectively. Its completely integrated engineering and production organization can, in effect, *compress time.*

With a balanced engineering team and an experienced production staff housed together in a facility built specifically for the development and manufacture of missiles, Fairchild can cut down lags in moving a missile project from the design and development phase into the production phase.

It *has* done so.



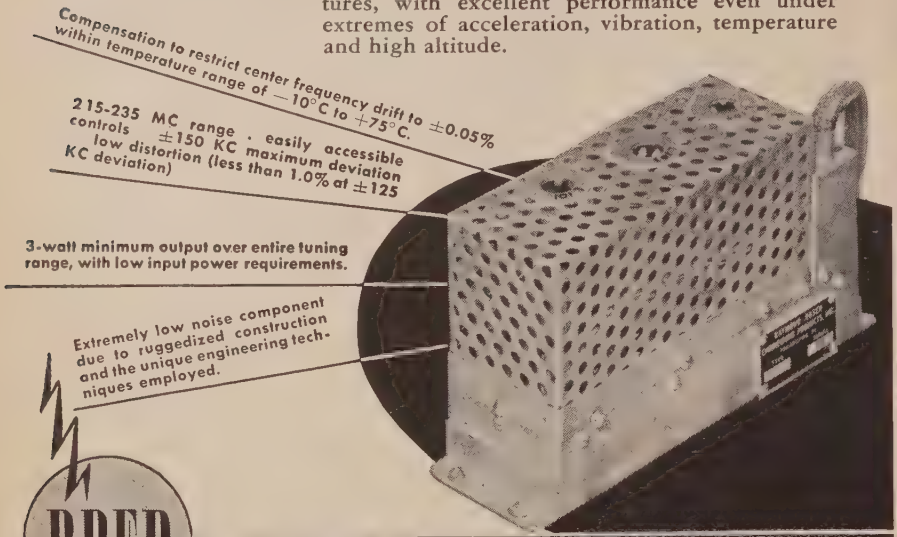
ENGINE AND AIRPLANE CORPORATION
FAIRCHILD
Guided Missiles Division
WYANDANCH, N. Y.

•

Aircraft Division, Hagerstown, Maryland • Engine Division, Farmingdale, N.Y.
Speed Control Division, Wickliffe, Ohio • Stratos Division, Bay Shore, N.Y.
AL-Fin Div., Farmingdale, N.Y.

RREP 840-A FM Transmitter

Light in weight, small in form factor, the 840-A FM Transmitter has been developed for airborne applications in the flight test field. This precision instrument incorporates many outstanding features, with excellent performance even under extremes of acceleration, vibration, temperature and high altitude.


Compensation to restrict center frequency drift to ±0.05% within temperature range of −10°C to +75°C.
215-235 MC range · easily accessible controls ±150 KC maximum deviation low distortion (less than 1.0% at ±125 KC deviation)
3-watt minimum output over entire tuning range, with low input power requirements.
Extremely low noise component due to ruggedized construction and the unique engineering techniques employed.

RREP

RAYMOND ROSEN ENGINEERING PRODUCTS, Inc.
32nd & Walnut Streets • Philadelphia 4, Pa.

TOP HAT FOR PLUG-IN UNITS

A widely used, dependable, improved clamp for electron tubes, relays and capacitors.

WRITE FOR 1953 CATALOG

EASY TO APPLY
INSTANTLY RELEASED
POSITIVE LOCKING ACTION

TIMES FACSIMILE CORPORATION
540 West 58 St., New York 19, N. Y.
1523 L St., N.W Washington 5, D. C.

ipc
ohmite
AMPHENOL
CANNON ELECTRIC
FTR FEDERAL TELEPHONE & RADIO

ARE YOU PARTICULAR?

So are we.
That is why we have
associated ourselves with only
the TOP manufacturers in the industry.

A NAME BUILT ON RESULTS—NOT PROMISES

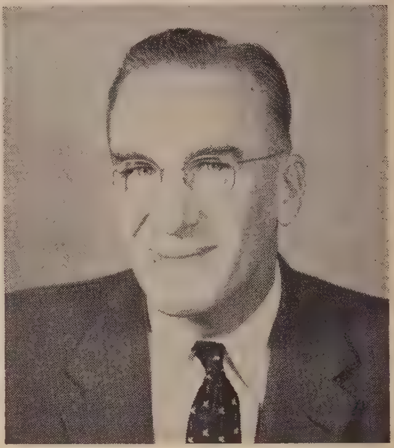
Schweber ELECTRONICS
122 HERRICKS ROAD, MINEOLA, L. I., N. Y. • GARDEN CITY 7-6520

News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

(Continued from page 127A)

Gates Appoints Colvin Director of Engineering



Announcement of the appointment of Mr. Jack Colvin as Director of Engineering of the **Gates Radio Co.**, was made by P. S. Gates, President. Mr. Colvin, prior to joining Gates, was Chief Engineer and Plant Manager of the Commercial Radio Company of New York, Chief Audio Engineer for the American Broadcasting Company and Systems Engineer for the Radio Corporation of America.

(Continued on page 141A)

Star Performers

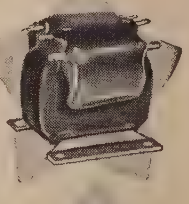
EPCO "QUALITY-PLUS"

TRANSFORMERS

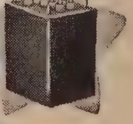
For Industrial and Electronic Equipment

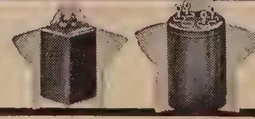
DESIGNED TO COMMERCIAL & MILITARY SPECIFICATIONS (MIL-T-27 and AN-E-19). ALSO CLASS A, B, H, AND MINIATURES.

Sample, Short and Long Runs. Let us quote on your specifications. No obligation. Delivery as promised!



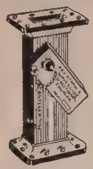
EPCO
PRODUCTS, INC.
2500 ATLANTIC AVE.
BROOKLYN 7, N. Y.





COMMUNICATIONS EQUIPMENT CO.

MICROWAVE COMPONENTS



"S Band," RG48/U Waveguide

POWER SPLITTER for use with type 726 or any 10 CM Shepherd Klystron. Energy is fed from Klystron antenna through dual pick-up system to 2 type "N" connectors..$22.50 **EACH**

DIRECTIONAL COUPLER. Broadband type "N" Coupling, 20 db. with std. flanges, Navy ‡CABV47AAN-2 (as shown) $37.50

LHTR, LIGHTHOUSE ASSEMBLY. Part of RT39 APG 5 & APG 15. Receiver and Trans. Cavities w/assoc Tr. Cavity and Type N CPLG. To Recvr. Uses 2C40, 2C43, 1B27, Tunable APX 2400-2700 MCS. Silver Plated $49.50

BEACON LIGHTHOUSE cavity p/o UPN-2 Beacon 10 cm. Mfg. Bernard Rice, each $47.50

MAGNETRON TO WAVEGUIDE Coupler with 721-A Duplexer Cavity, gold plated $45.00

RT-30 APG-5 10 cm. lighthouse RF head c/o Xmtr.-Recvr-TR, cavity compl. recvr. & 30 MC IF strip using 60K5 (2C40, 2C43, 1B27 lineup) w/Tubes.

721A TR BOX complete with tube and tuning plungers $12.50

McNALLY KLYSTRON CAVITIES for 707B or 2K28 ....$4.00

WAVEGUIDE TO ⅞" RIGID COAX 'DOOR-KNOB" ADAPTER CHOKE FLANGE, SILVER PLATED BROAD BAND $32.50

AS14A AP-10 CM Pick up Dipole with "N" Cables $4.50

OAJ ECHO BOX, 10 CM TUNABLE $22.50

HOLMDELL-TO-TYPE "N" Male Adapters, W.E. ‡D167284 ....$2.75

I.F. AMP. STRIP: 30 MC, 30 d.b. gain, 4 MC Bandwidth, uses 6AC7's—with video detector. A.F.C. less tubes $24.50

BEACON ANTENNA, AS31/APN-7 in Lucite Ball. Type "N" feed $22.50

ANTENNA, AT49A/APR: Broadband Conical, 300-3300 MC Type "N" Feed $12.50

"E" or "H" PLANE BENDS, 90 deg. less flanges $7.50

X Band— RG 52/U WAVEGUIDE

VSWR Measuring Section. Consisting of 6" straight section, with 2 pick-up, Type "N" Output Jacks. Mounted ½ Wave apart $8.50

1" x ½" waveguide in 5' lengths, UG 39 flanges to UG40 cover ....**per length $7.50**

Rotating-joints supplied either with or without deck mounting. With UG40 flanges **.each, $17.50**

Bulkhead Feed-thru Assembly $15.00

Pressure Gauge Section 15 lb. gauge and press nipple $10.00

Pressure Gauge, 15 lbs. $2.50

Directional Coupler, UG-40/U Take off 20db $17.50

TR-ATR Duplexer section for above $8.50

Waveguide Section 12" long choke to cover 45 deg. twist & 2½" radius, 90 deg. bend $4.50

Waveguide Section 3 ft. long silver plated with choke flange $5.75

Rotary joint choke to choke with deck mounting $17.50

90 degree elbows. "E" plane 2½" radius ..$12.50

Microwave Receiver, 3 CM. Sensitivity: 10-13μ Watts. Complete with L.O. and AFC Mixer and Waveguide Input Circuits. 6 I.F. Stages give approximately 120 DV gain at a bandwidth of 1.7 MC. Video Bandwidth; 2 MC. Uses latest type AFC circuit. Complete with all tubes, including 723A/B Local Oscillator $175.00

ADAPTER, waveguide to type "N", UG 81/U, p/o TS 12, TS-13, Etc. $27.50

ADAPTER, UG-163/U round cover to special btl. Flange for TS-45, etc. ....**$2.50 ea.**

K Band—½" x ¼" W.G. 1.25 CM.

APS-34 Rotating joint $49.50

Right Angle Bend E or H Plane, specify combination of couplings desired $12.00

45° Bend E or H Plane, choke to cover $12.00

Mitered Elbow, cover to cover $4.00

TR-ATR-Section. Choke to cover $4.00

Flexible Section 1" choke to choke $5.00

"S" Curve Choke to cover $4.50

Adapter, round to square cover $5.00

Feedback to Parabola Horn with pressurized window $27.50

90° Twist $10.00

JAN WAVEGUIDE FLANGES

UG 39/U $1.10
UG 40/U $1.25
UG 40A/U $1.65
UG 51/U $1.65
UG 52/U $3.40
UG 52A/U $3.40

MAGNETRONS

Type	Freq. Range(MC)	Peak Power Out (KW)	Duty Ratio	Price
2J21A	9345-9405	50		$8.75
2J22	3267-3333	265		7.50
2J27	2965-2992	275	.002	19.95
2J31	2820-2860	285	.002	24.50
2J32	2780-2820	285	.002	28.50
2J38*	3249-3263	5		16.50
2J39*	3267-3333	8.7		24.50
2J48	9310-9320	50	.001	24.50
2J49	9000-9160	50	.001	59.50
2J56*	9215-9275	50	.001	132.50
2J61†	3000-3100	35	.002	34.50
2J62†	2914-3010	35	.002	34.50
700B	690-700	40	.002	22.50
700D	710-720	40	.002	39.75
706EY	3038-3069	200	.001	32.50
706CY	2976-3007	200	.001	32.50
725-A	9345-9405	50	.001	Write
730-A	9345-9405	50	.001	24.50
4J38	3550-3600	750	.001	169.45

*—Packaged with magnet.
†—Tunable over indicated range.

5J23 ....$49
4J34 ....$125
QK-253 ..$249
3J3J $85

70 WATT C. W. MAGNETRONS*

QK-60 ....2800-3025 MC.
QK-61 ....2975-3200 MC.
QK-62 ....3150-3375 MC.
PRICE ....$85 Ea.

*Tunable, and packaged with magnet.

—IN STOCK—

AIA
APA-9
APA-10
APN-3
APN-7
APN-9*
APS-2
APS-3
APS-4
APS-6
ASD
ASH
BG
DAS†
DBS†
APT-2
APT-4
MKIV
MKX
RC145
RC148
SO-1
SO-8
SG-1
SJ-1
TAJ
TBK
TBL
SCR520*
SCR521
SCR518

* COMPONENTS. † LORAN EQUIPMENT

—TEST SETS—

TS-10
TS-36
TS-47
TS-12
TS-56
TS-34
TS-159
TS-268
TS-270

I. F. AMPLIFIER STRIPS

MODEL SO: 30 McGain figure is 120 db. Bandwidth: 2Mc. Uses 6 stages of 6AC7 Plus one video detector. Less Tubes $24.50

Model 15: 30 Mc center frequency, Bandwidth 2.5 Mc. gain figure: 65 db. Uses 5 stages of 6AC7's. Has D. C. Restorer and Video Detector. A.F.C. Strip included. Input impedance: 50 Ohms. Less tubes $27.50

Model APS-4: Miniature IF strip, using 6AK5's 60 Mc center Freq. Gain: 95db at Bandwidth of 2.7 Mc. Less tubes $45.00

THERMISTORS

D-164699 Bead Type DCR: 1525-2550 Ohms @ 75 Deg. F. Coefficient: 2% Per Deg. Fahr. Max. Current 25 MA AC/DC $2.50

D-167332 Bead Type, DCR is 1525-2550 Ohms. Rated 25 MA at .825-1.175 VDC $1.35

D-167613 Disk Type DCR: 355 Ohms @ 75 Deg. F.P.M. 2.5%, 1 Watt $1.35

D-166228 Disk Type 7120 Ohms @ 60°F. 4220 Ohms @ 80°F. 2590 Ohms @ 100°F., 1640 Ohms @ 120°F. $1.35

PULSE NETWORKS

15A—1-400-50: 15 KV. "A" CKT. 1 microsec. 400 PPS. 50 ohms imp. $37.50

G.E. ‡3E (3-84-810) 8-2.24-405) 50P4T ; 3KV "E" CKT Dual Unit; Unit 1, 3 sections, 0.84 Microsec. 810 PPS, 50 ohms imp.; Unit 2, 8 Sections, 2.24 microsec. 405 PPS 50 ohms imp. $6.50

7-5E3-1-200-67P. 7.5 KV "E" Circuit, 1 microsec. 200 PPS. 67 ohms impedance 3 sections $7.50

7-5E4-16-60, 67P. 7.5 KV "E" Circuit, 4 sections 16 microsec. 60 PPS, 67 ohms impedance $15.00

7-5E3-3-200-67P, 7.5 KV. "E" Circuit, 3 microsec. 200 PPS. ohms imp. 3 sections $12.50

‡755: **10KV.** 2.2usec., 375 PPS. 50 ohms imp. ...$27.50

‡754: **10KV.** 0.85usec., 750 PPS. 50 ohms imp. .. $27.50

KS8865 CHARGING CHOKE: 115-150 H @ .02A, 32—40H @ .08A. 30.700V Corona Test. 21KV Test $37.50

G.E. 25E5-1-350-50 P2T. "E" SKT, 1 Microsec. Pulse @ 350 PPS. 50 OHMS Impedance $69.50

KS9623 CHARGING CHOKE: 16H @ 75 MA, 380 Ohms DCR. 9000 Vac test $14.95

G.E. 6E3-.5-2000 50 P2T: 6 KV., "E" Circuit 0.5 usec /2000 PPS/50 ohms/2 sections $7.50

PULSE EQUIPMENT

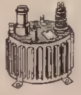
MIT. MOD. 3 HARD TUBE PULSER: Output Pulse Power 144 KW (12 KV at 12 Amp). Duty Ratio: .001 max. Pulse duration: 5, 1.0, 2.0 microsec. Input voltage: 115 v. 400 to 2400 cps. Uses: 1-71B, 4-89-B, 3-'72's, 1-'73. New ....Less Cover—$135

TPS-3 PULSE MODULATOR. Pk. power 50 amp. 24 KW (1200 KW pk): pulse rate 200 PPS. 1.5 microsec. pulse line impedance 50 ohms. Circuit series charging version of DC Resonance type. Uses two 705-A's as rectifiers. 115 v. 400 cycle input. New with all tubes $49.50

PULSE TRANSFORMERS

RAYTHEON WX 4298E: Primary 4KV., 1.0 USEC. SEC: 16KV-16 AMP DUTY RATIO: .001 400 CYCLE FIL. TRANS. 'BUILT-IN" $42.50

WECO: KS 9948: Primary 700 ohms; Sec: 50 ohms. Plate Voltage: 18 KV. Part of APQ-13 ....$12.50



GE ‡K-2449A
Primary: 9.33 KV, 50 ohms Imp.
Secondary: 28 KV, 450 ohms.
Pulse length: 1.0/5 usec @ 635/120 PPS. Pk Power Out: 1.740 KW
Bifilar: 1.5 amps (as shown) ...$62.50

GE ‡K-2748-A. 0.5 usec @ 2000 Pps. Pk. Pwr. out is 32 KW impedance 40:100 ohm output. Pri. volts 2.3 KV Pk. Sec. volts 11.5 KV Pk. Bifilar rated at 1.3 Amp. Fitted with magnetron well $39.50

K-2745 Primary: 3.1/2.8 KV, 50 ohms Z. Secondary: 14/12.6 KV 1025 ohms Z. Pulse Length: 0.25/1.0 usec @ 600/600 PPS. Pk. Power 200/150 KW. Bifilar: 1.3 Amp. Has "built-in" magnetron well $42.50

K-2461-A. Primary: 3.1/2.6 KV—50 ohms (line). Secondary 14/11.5 KV—1000 ohms Z. Pulse Length: 1 usec @ 600 PPS. Pk. Power Out: 200/130 KW. Bifilar: 1.3 Amp. Fitted with magnetron well .$39.75

UTAH X-151T-1: Dual Transformer, 2 Wdgs. per section 1:1 Ratio per sec 13 MH inductance 30 ohms DCR $7.50

UTAH X-150T-1: Two sections, 3 Wdgs. per section. 1:1:1 Ratio, 3 MH, 6 ohms DCR per Wdg. $7.50

68G711: Ratio: 4:1 Pri: 200V, Sec. 53V, 1.0 usec Pulse @ 2000 PPS, 0.016 KVA $4.50

TR1049 Ratio: 2:1 Pri. 220 MH, 50 Ohms, sec. 0.75 H. DCR 100 Ohms $6.75

K-904695-501: Ratio 1:1. Pri. Imp. 40 Ohm, Sec. Imp. 40 Ohms. Passes pulse 0.6 usec with 0.05 usec rise $8.95

Ray UX 7896—Pulse Output Pri, 5v sec. 41v $7.50

Ray UX 8442—Pulse inversion—40v + 40v $7.50

PHILCO 352-7250. 352-7251. 352-7287

RAYTHEON: UX8693. UX5986 ....$5 ea.

W.E.: D-166310, D-166638, KS9800, KS9948.

UTAH ‡9262, with Cracked Beads, but will operate at full rated capacity $5.00

UX 8693 (SCS ‡2Z9627-54); 3 Wdgs, 32 turns ‡18 wire. DCR is: 362/.372/.4 ohms. Total voltage 2500 vdc. $5.00

D-166173: Input: 50 ohms Z. Output: 900 ohms 3 Wdgs. Freq range 10 kc-2mc. P/0 AN/APQ*-13 $12.50

K-2450: Pulse-inversion auto-transformer: primary 13 kv, 4 usec. Output: 14 kv @ 100 kw peak $34.50

MICROWAVE ANTENNAS

AT49/APR—Broadband Conical. 300-3300 MC. Type N Feed $8.95

AS-31/APN-7: 10 cm Polyrod in Lucite Ball. Type N Fitting Coax Feed $22.50

Relay System Parabolic reflectors approx. range 2000 to 6000 Mc. Dimensions 4½" x 3'. New $100.00

Dipole for above $12.00

Parabolic Peel. Radiation pattern approx. 25 deg. in horizontal 33 deg. in vertical planes $35.00

Cone Antenna. AS 125 APR. 1000-3200 mc. Stub supported with type "N" connector $14.50

AS14A/AP, 10 CM pick up dipole assy, complete w/length of coax and "N" connectors $4.50

AS46A/APG-4 Yagi Antenna, 5 element array ..$22.50

30" Parabolic Reflector Spun Aluminum dish $485

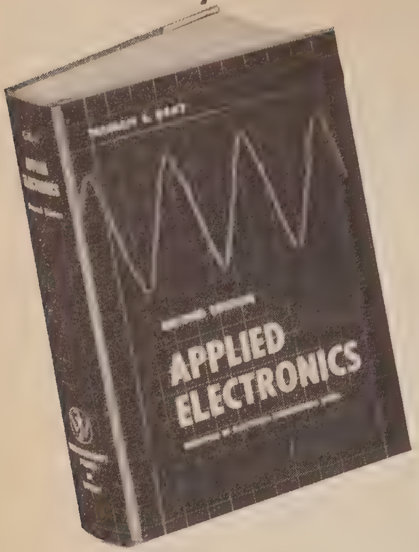
APS-34 Pillbox Antenna, waveguide input: 24.000-27.000 MC $22.50

SCR 584, Dishes Perforated, Metal Construction $185.00

MAIL ORDERS PROMPTLY FILLED. ALL PRICES F.O.B. NEW YORK CITY. SEND M.O. OR CHECK. ONLY SHIPPING SENT C.O.D.
RATED CONCERNS SEND P.O. ALL MDSE. SUBJECT TO PRIOR SALE, AND PRICES SUBJECT TO CHANGE WITHOUT NOTICE.
PARCELS IN EXCESS OF 20 POUNDS WILL BE SHIPPED VIA CHEAPEST TRUCK OR RAILEX.

131 Liberty St., New York 7, N. Y. Dept I-4 Chas. Rosen Phone: Digby 9-4124

Now ready . . .



APPLIED ELECTRONICS

2nd Edition

A Publication in *The Principles of Electrical Engineering Series,* M.I.T.

By TRUMAN S. GRAY
The Massachusetts Institute of Technology

THE 2nd edition of this classic work retains the purpose and much of the plan of the first edition. The major aims in its revision have been: to improve and clarify details; to bring the coverage up to date; and to include new developments such as semiconductor rectifiers and transistors.

It first explains the physical phenomena which form the fundamentals of electronics, then tells how the phenomena combine to govern the characteristics, ratings and limitations of electronic devices. Final chapters deal with various applications of electronics in different branches of electrical engineering.

Applied Electronics presents a clear picture of the subject, starting from elementary facts and principles. For those who have already gained a basic knowledge, its foundational treatment and practical illustrations and problems will provide a useful means for further study and reference.

1954 882 pages Illus. $9.00

Mail Now for Your Copy ON APPROVAL

JOHN WILEY & SONS, Inc.
440 Fourth Avenue, New York 16, N.Y.

Please send ON APPROVAL a copy of Gray's APPLIED ELECTRONICS, 2nd Edition. Within 10 days I will either return the book and owe you nothing or will remit $9.00 plus postage.

Name . . . .
Address . . . .
City . . . . .Zone . . . .State . . . . .

☐ SAVE POSTAGE. Check here if you ENCLOSE $9.00, in which case we pay postage. Same return privilege.

(P IRE-44)

MEMBERSHIP

(Continued from page 136A)

Clausen, R. P., Sylvania Electric Products, Inc., Emporium, Pa.
Eaton, R. C., 214 Shaver Ave., North Syracuse, N. Y.
Gaither, L. E., Evans Signal Laboratory, Belmar, N. J.
Gunter, F. B., Westinghouse Electric Corp., 2519 Wilkens Ave., Baltimore 3, Md.
Humphrey, R. A., 608 Upper Mountain Ave., Upper Montclair, N. J.
Jeffers, N. L., 46 N. Arlington Ave., East Orange, N. J.
Kronenberg, M. H., 82-27—217 St., Queens Village, L. I., N. Y.
Lash, C. C., 1111 East 25 St., Tulsa 5, Okla.
MacKenzie, J. E., 833 Stamford Rd., Baltimore 29, Md.
Markin, J., 2309 Sherman Ave., Evanston, Ill.
Mills, B. E., A.T.I. Branch/H.Q., USAFE/APO 633, c/o Postmaster, New York, N. Y.
Nielsen, J. O., 48, Mylius Erichsens Alle, Hellerup, Denmark
Patterson, H. R., 2630 Eighth Ave., Oakland, Calif.
Supitilov, M. C., 318 Gray St., St. Charles, Ill.
Sussman, H., U.S.N. Underwater Sound Laboratory, New London, Conn.
Tallman, O. G., 102 Ringdahl Ct., Rome, N. Y.
Williams, P. B., 181 E. Harvard St., Elmhurst, Ill.
Woloschak, K., 20 Pilgrim Dr., Port Chester, N. Y.

Transfer to Member

Auerbach, B., 340 Carteret St., Camden 3, N. J.
Beazell, H. L., Jr., 2316 Stadium Rd., Charlottesville, Va.
Bein, W., 610 Riverside Dr., New York 31, N. Y.
Bettan, M. I., 70-33 Park Dr., E., Kew Garden Hills, L. I., N. Y.
Boden, E. H., R.F.D. 1, Emporium, Pa.
Burwen, R. S., 17 Sheffield Rd., Melrose 76, Mass.
Crawford, B., Box 561, 844 N. 13 Ave., Broken Bow, Neb.
Davidson, G. M., 2259 Creston Ave., New York 53, N. Y.
Davidson, F. A., 225 Charles St., Cincinnati 15, Ohio
Dick, J. O., 3585 Nelson St., Riverside, Calif.
Dumas, J. E., 10 Levis Ave., Apt. 1, Quebec 6, Que., Canada
Files, W. D., 405 Martin Ter., State College, Pa.
Flore, I., 270 Jay St., Brooklyn 1, N. Y.
Fraser, J. T., 4821 Eldon Green, Baltimore 27, Md.
Gordon, A. D., 514 W. Walnut St., Lancaster, Pa.
Guichard, R. S., 908 Savilla Ave., Fort Wayne, Ind.
Jamieson, R. T., Geophysical Research Institute, Witwatersrand University, Milner Park, Johannesburg, South Africa
King, M., 73-67—136 St., Flushing 67, L. I., N. Y.
Lawrence, E., 50 Borkwood Way, Orpington, Kent, England
Levin, S., 186 N. Clark Dr., Beverly Hills, Calif.
Luber, L., 221 Fountain Ave., Brooklyn 8, N. Y.
McKay, G. C., Jr., 7517 Bradford St., Houston 17, Tex.
Murphree, F. J., Jr., 903 Ridgeway Dr., Huntsville, Ala.
Olney, V. W., 73 Marigold Ave., Buffalo 15, N. Y.
Pappas, N. L., Box 738D, R.F.D. 1, Los Altos, Calif.
Rambo, L. W., Code 223, Bureau of Ships, Navy Department, Washington 25, D. C.
Redler, W. M., 11914 Andrew St., Silver Spring, Md.
Robinson, I. E., 10 Barry La., Wallingford, Pa.
Rochefort, J. S., 501 Washington St., Brighton 35, Mass.
Schwartz, M., 1977 Prospect Ave., New York 57, N. Y.
Shahan, O., 1727 Scott Rd., Apt. H, Burbank, Calif.

(Continued on page 143A)

PROFESSIONAL CARDS

ALFRED W. BARBER LABORATORIES
Specializing in the Communications Field and in Laboratory Equipment
Offices, Laboratory and Model Shop at:
32-44 Francis Lewis Blvd., Flushing, L.I., N.Y.
Telephone: Independence 3-3306

Edward J. Content, P.E. and Staff
INTERNATIONAL RADIO CONSULTANTS
Pan American Radio Bldg., 16 Rue Delacroix
Tangier Int'l Zone Morocco
Specialized in the design, construction, foreign, Electronic, projects, and advising governments at Int'l Telecommunications Union.

CROSBY LABORATORIES, INC.
MURRAY G. CROSBY & STAFF
RADIO-ELECTRONIC RESEARCH
DEVELOPMENT & MANUFACTURING
COMMUNICATIONS, FM & TV
ROBBINS LANE
HICKSVILLE, NEW YORK
HICKSVILLE 3-3191

INTERFERENCE MEASUREMENT SERVICES
OF
DYNAMIC ELECTRONICS—N.Y., INC.
Director—H. S. BENNETT, DR. ENG., P.E.
Specialists in determining equipment compliance with government radio interference specifications.
73-39 WOODHAVEN BLVD.
GLENDALE, L.I. IL-9-7000

ELDICO OF NEW YORK, INC.
Donald J. S. Merten and Engineering Staff
Consultants on Interference Elimination from Transmitters, Induction Heaters, Diathermy, etc.
44-31 Douglaston Parkway, Douglaston, L.I., N.Y.
Bayside 9-8686

ELECTRO-METRIC INSTRUMENT CO.
A. Newton, Director of Eng.
Circuit analysis, design and development in the fields of VHF, UHF tuners, TV receivers and accessories, laboratory and test instrumentation.
241 Centre Street, New York 13, N.Y.
Canal 6-1337

Richard B. Schulz
Electro-Search
Radio-Interference Reduction;
Development of
Interference-Free Equipment,
Filters, Shielded Rooms
4337 N. 5th Street, Philadelphia 40, Pa.
GLadstone 5-5353

ELECTRONIC RESEARCH ASSOCIATES, INC.
N. J. GOTTFRIED
'Transistorize' Your Product!
Complete Service in consulting, research, development, and production on Transistor circuitry, products, and instrumentation.
715 Main Street North Caldwell, N.J.
Ca-6-6729

ELK ELECTRONIC LABORATORIES, INC.
Jack Rosenbaum
Specializing in design and development of Test Equipment for the communications, radar and allied fields
333 West 52nd St., New York 19, PL-7-0520

PROFESSIONAL CARDS

F-R MACHINE WORKS
INC
ELECTRONICS FXR X-RAY DIVISION
DESIGN - DEVELOPMENT
Charles Zavales - John Ebert
44-14 Astoria Boulevard Long Island City 3, N.Y.
Phone AStoria 8-2800

FREDERICK RESEARCH CORP.
BETHESDA 14, MARYLAND
Carl L. Frederick, D.Sc., Pres.
Tel: Washington, D.C., OLiver 4-3229
Research, Specifications, Development, Engineering, Manufacture, Technical Writing, Offset Printing—Fields of Test Equipment, Radio Interference, Tuners, Circuits, Electromechanical Systems, Components.

PAUL GODLEY CO.
Consulting Radio Engineers
P.O. Box J, Upper Montclair, N.J.
Offs & Lab.: Great Notch, N.J.
Phone: Montclair 3-3000
Established 1926

GOVERNMENT CONTRACT LIAISON AND CONSULTANTS
GORDON ASSOCIATES, INC.
Specializing in Signal Corps Electronic Requirements, Technical Manuals, Tabular List of Parts, Drawings
L. Gordon, Pres. P. Treston, Ch. Engr.
157 Broad Street Telephone
Red Bank, New Jersey Red Bank 6-2743

HIGHLAND ENGINEERING CO.
William R. Spittal & Staff
Design, Development and Manufacture of Transformers, Chokes, Etc.
for the
Electronic, Industrial and Allied Fields
Main & Urban, Westbury, L.I., N.Y.
WE-7-2933

HOGAN LABORATORIES, INC.
John V. L. Hogan, Pres.
APPLIED RESEARCH, DEVELOPMENT, ENGINEERING
Est. 1929. Electronics, Optics, Mechanisms, Facsimile Communication, Digital Computers, Electro-sensitive recording media, Instrumentation.
155 Perry Street, New York 14 CHelsea 2-7855

LEONARD R. KAHN
Consultant in Communications and Electronics
Single-Sideband and Frequency-Shift Systems
Diversity Reception - Modulation Theory
Applications of Magnetic Tape Recording
Elizabeth Bldg., 22 Pine St., Freeport, L.I., N.Y.
Freeport 9-8800

HARRY R. LUBCKE
CONSULTING TELEVISION ENGINEER
Television Engineering Since 1929
Electronics
2443 CRESTON WAY HO. 9-3266
HOLLYWOOD 28, CALIFORNIA

McKAY ELECTRIC CO.
Research and Manufacturing Engineers
James R. Walker M. H. McKay
Specialists in Magnetic Servo Amplifiers and Regulators
19790 Stahelin Ave.
Detroit 19, Mich.

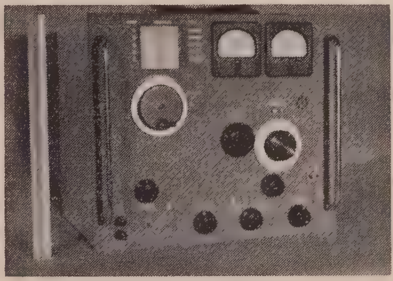
News—New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your I.R.E. affiliation.

(Continued from page 138A)

FM Signal Generator

A.R.F. Products, Inc., 7627 Lake St., River Forest, Ill., has designed a new FM signal generator with a frequency range of 20 to 100 mc in five bands.



The generator has a stable oscillator circuit which is coupled inductively to a piston-type attentuator. Reactance-tube modulation enables undistorted FM deviations up to 100 kc, a special bridge circuit to eliminate hum originating in the reactance-tube heater circuit has been developed. Compensation of deviation calibration at all ranges is accomplished by means of an additional variable capacitor section in the main tuning circuit. A low-distortion audio oscillator is provided for internal modulation. Calibration is provided by reference to the spectrum of harmonics generated by a 2-mc crystal controlled oscillator.

Calibrated output is 0.05 μ volts to 100,000 μ volts in 50 ohms external impedance calibrated to the accuracy of 2 db (internal impedance is 50 ohms). Frequency deviation is adjustable from 0 to over 150 kc with maximum "undistorted" deviation of 100 kc.

PROFESSIONAL CARDS

MEASUREMENTS CORP.
RESEARCH & MANUFACTURING ENGINEERS
Harry W. Houck M. A. Honnell
John M. van Beuren
Specialists in the Design and Development of Electronic Test Instruments
BOONTON, N.J.

L. J. CASTRIOTA M. WIND
S. W. ROSENTHAL P. G. MARIOTTI
Microwave Consultants
Radio Frequency and Microwave Components
Cable—Waveguide—Coax
Telephone G.P.O. Box 844
BOulevard 3-2096 Brooklyn 1, N.Y.

Microwave Development Laboratories Inc.
Henry J. Riblet, Pres.
Design, Development and Fabrication of Waveguide Components
Waltham 5-6708 220 Grove Street
Waltham 5-7725 Waltham, Mass.

PROFESSIONAL CARDS

E. V. NAYBOR
Consultant on Electro-Magnetic Devices
Relays, Solenoids, Actuators and Associated Equipment
Design-Development-Prototypes
Test Equipment
30 Manorhaven Blvd., PO. 7-2676
Port Washington, N.Y.

EVERT M. OSTLUND
Consulting Radio Engineer
Radio—Microwave
Communication—Control
Systems and Equipment
Planning, Research, Development
ANDOVER, NEW JERSEY
Tel: Lake Mohawk 8635

PSC APPLIED RESEARCH LTD.
Development & Production
AIRCRAFT and INDUSTRIAL
INSTRUMENTS ● AIDS ● SYSTEMS
Navigation - Survey - Processing - Servo
Gyro - Photo - Magnetic - Electronic
Radiation - Optical
J. M. Bridgman, General Manager
1450 O'Connor Drive Toronto, Canada

PICKARD AND BURNS, INC.
Consulting Electronic Engineers
Analysis and Evaluation of Radio Systems
Research, Development, Design and Production of Special Electronic Equipment and Antennas.
240 Highland Ave. Needham 94, Mass.

Paul Rosenberg Associates
Consulting Physicists
100 STEVENS AVE. ● MOUNT VERNON, NEW YORK
CABLE: PHYSICIST Mount vernon 7-8040

TELECHROME, INC.
Electronic Design Specialists
COLOR TV INSTRUMENTATION AND BROADCAST EQUIPMENT
Flying Spot Scanners, Color Synthesizers, Keyers, Monitors, Oscilloscopes and Related Apparatus
J. R. Popkin-Clurman, Pres. & Ch. Engr.
88 Merrick Rd. Amityville, L.I., N.Y.

TELREX, INC.
M. D. Ercolino, Pres.
H. F. ANTENNA SPECIALISTS
Communication Arrays
Reception or Transmission
For FM, TV, and Amateur Service.
Asbury Park, N.J.—Phone AP 2-7252

VRL **VIBRATION RESEARCH LABORATORIES, INC.**
VIBRATORS ● VIBRATOR POWER SUPPLIES
● 42 OAK AVENUE
● TUCKAHOE, N. Y.
J. A. Mas, Chief Engineer ● TUckahoe 3-5502

WHEELER LABORATORIES, INC.
Radio and Electronics
Consulting — Research — Development
R-F Circuits — Lines — Antennas
Microwave Components—Test Equipment
Harold A. Wheeler and Engineering Staff
Great Neck, N.Y. HUnter 2-7876

Clevite Germanium Diodes

127 TYPES!

JUNCTION PHOTODIODE
1N188 TYPE
"DIOMITE" BEAD TYPE
31 TYPES
CARTRIDGE TYPE
TP
CLEVITE
60 TYPES
"MICROTEMP" CAN TYPE
35 TYPES

CLEVITE DIODES
offer all these features!

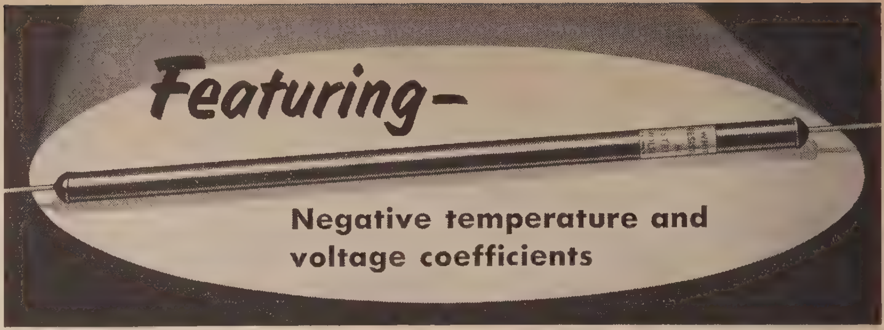
Widest Range of Types available anywhere, Extremely Long Operating Life, Universal Lead Mounting — *at no extra cost*, Positive Electrical Stability, Advanced Hermetic Sealing, Uniformly Low Inter-Electrode Capacitance, Micro-sized, Ruggedly built.

Precision Tested — Low Cost
HUNDREDS OF APPLICATIONS!

As Rectifiers — Detectors — Discriminators — Limiters — Multipliers — Modulators — Switches — and many other new, important uses being discovered daily!

For data sheets and complete information on CLEVITE transistors, diodes and transistor test sets, write Dept. P4.

TRANSISTOR PRODUCTS, INC.
SNOW AND UNION STREETS, BOSTON 35, MASSACHUSETTS
AN OPERATING UNIT OF
CLEVITE CORPORATION



S.S.WHITE 80X Molded Resistors

3 watts — 100 to 100,000 megohms

S.S.White 80X Resistors have been developed to meet the exacting needs of high voltage equipment, such as electrostatic generators, X-Ray units, and specialized equipment used in atomic energy work. Their design and construction assures an unusually fine combination of characteristics for this work, chief among which are:

- Negative temperature coefficients.
- Negative voltage coefficients.
- Excellent stability, durability and mechanical strength.
- Non-deterioration of values due to age.
- Moisture resistant, non-hygroscopic base material specially processed to insure full protection against humidity.
- Space-saving compactness.

WRITE FOR BULLETIN 4906 — It contains full information on S.S.White 80X resistors. Copy sent on request.

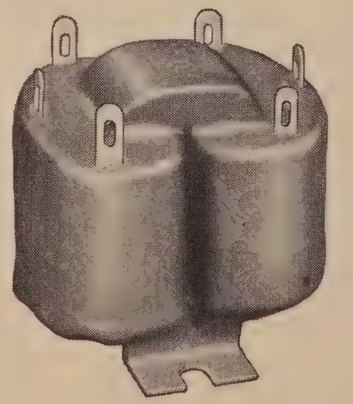
S.S.White
RESISTORS

THE S.S.White INDUSTRIAL DIVISION
DENTAL MFG. CO.
Dept. GR, 10 East 40th St.
NEW YORK 16, N.Y.

Western District Office • Times Building, Long Beach, California

---

PLASTIC ENCAPSULATED TRANSFORMERS



To meet the need for transformers finished in any one of several tested plastic formulations, Acme Electric have complete production facilities as well as experienced personnel and supervisory engineers to produce this class of equipment.

We invite your inquiries with specifications.

ACME ELECTRIC CORPORATION
444 WATER ST. • CUBA, N. Y.
West Coast Engineering Laboratories:
1375 W. Jefferson Blvd., Los Angeles, California
In Canada: Acme Electric Corp. Ltd.
50 Northline Road, Toronto, Ontario

Acme ACME Electric
TRANSFORMERS

MEMBERSHIP

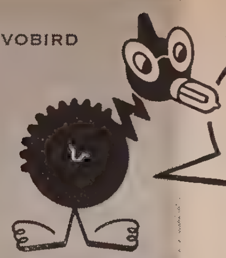
(Continued from page 140A)

Skarbek, I. R., 320 Riverside Dr., Hateauguay, Nr. Montreal, Que., Canada
Steele, A. J., 2151 W. Windsor St., Chicago, Ill.
Twombly, B. B., 21 Hillsdale Rd., Medford 55, Mass.
Ussler, W., Jr., 305 Meehan Ave., Philadelphia 19, Pa.
Walker, H. C., 3353—48 Loop, Sandia Base, Albuquerque, N. Mex.
Weaver, C. W., 116 Bellefonte, Ashland, Ky.
Weden, C. V., Jr., Machlett Laboratories, Inc., Springdale, Conn.
Wiener, A. M., 318 Euclid Ave., Loch Arbour, Asbury Park, N. J.
Winston, G. C., 5704 Abbott Dr., Temple Hills, Washington 21, D. C.
Wolking, D. H., 9333 S. Barkerville Ave., Whittier, Calif.

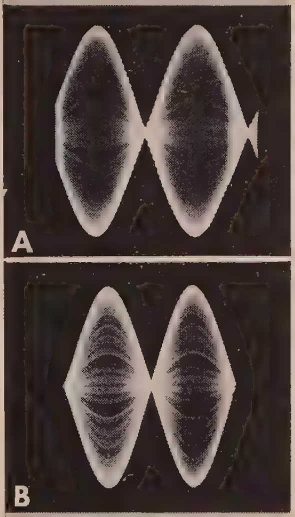
Admission to Member

Allison, R. F., Box 600, Great Barrington, Mass.
Altes, S. K., 2014 E. Genesee St., Syracuse 10, N. Y.
Ault, C. F., 45 Breglawn Dr., Clifton, N. J.
Belanger, F., c/o Royal Electric, Inc., Germantown, Ohio
Bloomberg, H., 877 E. Ninth St., Brooklyn 30, N. Y.
Brenner, R. A., 121-25—237 St., Laurelton 10, L. I., N. Y.
Briana, A. M., 14 Littlefield St., Quincy 69, Mass.
Bruck, L., 19 Promenade, Ulm/Donau (14a), Germany
Burmeister, M. A., 134 S. LaSalle St., Chicago 3, Ill.
Cahn, B. L., 3602—35 Ave., Long Island, L. I., N. Y.
Clark, D. P., Hazeltine Electronics Corp., 58-25 Little Neck Pkwy., Little Neck, L. I., N. Y.
Davis, W. W., 6240 Riverside Ave., Riverside, Calif.
DeHorn, C. E., 2729 Western Ave., Park Forest, Ill.
DeZonia, W. J., 3300 Magnolia, Denver 7, Colo.
Durkee, R. W., 3617 Stancrest Dr., Glendale 8, Calif.
Fabiszewski, H., 560 Tait, Ville St. Laurent, Que., Canada
Fellendorf, G. W., Instruments for Industries, Inc., Old Country Rd., Mineola, L. I., N. Y.
Foster, A. D., 118 Monee Rd., Park Forest, Ill.
Fullerton, A. L., Jr., Concord Rd., South Lincoln, Mass.
Gerbi, H. S., 213 Litchfield St., Torrington, Conn.
Gordon, C. K., 1216 Broadway, New Orleans 18, La.
Graves, P. P., 73 Court St., Augusta, Me.
Gray, J. C., c/o General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Grebe, J. J., The Dow Chemical Co., Midland, Mich.
Griffiths. O. H., 2456 Hartland Ave., St. Louis 14, Mo.
Grimsdale, R. L., "Lingerwood," 28, Thornfield Rd., Heaton Mersey, Stockport, England
Hall, W. W., Jr., H.Q., Signal Corps, Engineering Laboratories, Fort Monmouth, N. J.
Halpern, H. S., 850 W. Argyle St., Chicago 40, Ill.
Hedges, C. P., 4761 Imlay Ave., Culver City, Calif.
Heithecker, L. F., 1555 N. St. Clair, Wichita, Kan.
Hood, I. A., 1001 St. Paul St., Apt. C12, Baltimore, 2, Md.
Howe, R. M., 3439 Richard, Pittsfield Village, Ann Arbor, Mich.
Jackson, R. W., 48 Livingston St., New Haven 11, Conn.
Jeynes, W. E., 280 Caroline St., S., Apt. 1, Hamilton, Ont., Canada
Knight, M. B., 31 Chestnut St., East Orange, N. J.
Krone, I., 830 Westholme Ave., Los Angeles 24, Calif.

(Continued on page 144A)


SERVOBIRD

Is Your Servo Nonlinear?
Is the Output of Your
L-F Amplifier Distorted?



THE SERVOSCOPE®
is Your Solution

The Servoscope gives you phase and amplitude characteristics even when the wave forms are not sweet and clean sine waves.
The phase dial is rotated until the oscillogram **(A)** becomes symmetrical, as at **(B)**, and presto — you have your answer!
Degree and type of distortion are visible, too.
For detailed information on how this versatile test instrument can save you man-hours, write Dept. IRE-4.

SC112

SERVO CORPORATION OF AMERICA
NEW HYDE PARK, NEW YORK

SECON

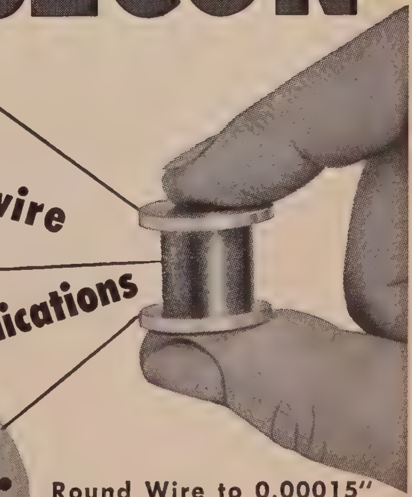
round • • oval flat • • grooved ribbon •

precision small wire

bare • • insulated plated •

for highly engineered applications

all metals • • all alloys



Round Wire to 0.00015" diameter. Ribbon rolled to 0.0001" in thickness. Close tolerances held on all specifications.

SECON
. . . wherever the element calls for PRECISION

development and production metallurgists
SECON METALS CORPORATION
7 Intervale Street, White Plains, New York
WHite Plains 9-4757

Write for Pamphlet P

Here's BIG HELP IN
TERMINAL WIRING!

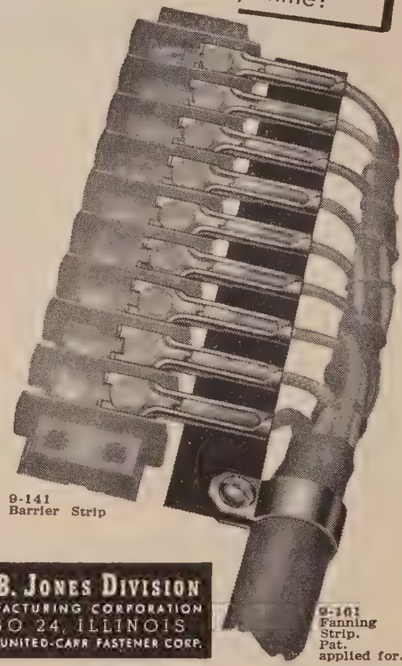
The New **JONES**
FANNING STRIP

The correct wire to correct terminal every time!

Connections are made through Fanning Strip, on bench or anywhere apart from barrier strip, and quickly slipped into assembly.

Designed for use with Jones Barrier Terminal Strips Nos. 131 and 142, for 1 to 20 terminals.

Simplifies and facilitates soldering. Insures positive correct connections. Saves time. Ideal for harness or cable assembly. Strong construction: Brass terminals, cadmium plated. Heavy bakelite mounting.



9-141 Barrier Strip

9-161 Fanning Strip. Pat. applied for.

Send for complete data on this new basic improvement!

Jones

HOWARD B. JONES DIVISION
CINCH MANUFACTURING CORPORATION
CHICAGO 24, ILLINOIS
SUBSIDIARY OF UNITED-CARR FASTENER CORP.

Complete Reliability
from **−70°** *to* **+150°C.**

WELWYN
High Stability
DEPOSITED CARBON RESISTORS

with the New, Improved **'PANCLIMATIC'** *Coating*

This new protective coating permits the use of these resistors under the greatest extremes of temperature. In addition, it affords better moisture protection for greater stability. It resists abrasion and impact with no tackiness, and it is chemically inert to common solvents and plasticizers. Storage stability is better than 1%. Operating at 50% nominal rating, and at an ambient temperature of 100°C, the stability of these 'Panclimatic' Coated resistors is better than 1%.

The same high standards of design, construction, and performance which have established Welwyn as a leading name in the field of precision resistors, will also identify these newly developed products.

For complete data and specifications write to Dept. GD-4

ROCKBAR CORPORATION
215 East 37th Street, New York 16, N. Y.

Manufactured in England and Canada

MEMBERSHIP

(Continued from page 143A)

Landis, V., Jr., 3439 Roxanne Ave., Long Beach 8, Calif.
LaPorte, G. L., Production Engineering, I.B.M. Corp., South Rd., Poughkeepsie, N. Y.
Larson, M. H., 235 W. El Sur, Monrovia, Calif.
Mahan, O. C., Box 223, R.F.D. 6, Mobile, Ala.
Malsch, J. R., Fa. Telefunken, Soeflinger Strasse, Ulm (Donau), (14a), Germany
Martin, R. A., 121-B Beverly Ct., Los Angeles 49, Calif.
May, R. W., 107 Meadowbrook Dr., North Syracuse, N. Y.
McCampbell, C. B., 6022 Princess Jeanne, N.E., Albuquerque, N. Mex.
McCarty, E. W., Box 83, R.F.D. 1, Port Blakely, Wash.
Meara, V. T., 1811 Northern Pkwy., Baltimore 12, Md.
Mederos, T. S., Jr., Applied Science Corporation of Princeton, Box 44, Princeton, N. J.
Mueller, W. J., Court St. Rd., East Syracuse 4, N. Y.
Myre, W. C., 441 Texas, S.E., Albuquerque, N. Mex.
Nielsen, C. L., 3618 N. Fair Oaks Ave., Altadena, Calif.
O'Hanlon, D. M. V., British European Airways, Keyline House, RUISLIP, Middx., England
Petermann, L. A., 39B Linden Ave., Metuchen, N. J.
Pinter, P. J., 3 Dewey Rd., Cheltenham, Pa.
Poff, J. K., 7 Brookside Ter., North Caldwell, N. J.
Prawdzik, C. A., 20 Riker Hill Rd., Livingston, N. J.
Rexon, L., 34 E. Central Ave., Moorestown, N. J.
Rigg, R. W., Corning Glass Works, Corning, N. Y.
Roark, G. L., General Electric Co., Bldg. 267, Schenectady, N. Y.
Robinson, D. F., 732 Maryland Ave., Lancaster, Ohio
Rolfs, J. C., 9 Park West, New Hyde Park, L. I., N. Y.
Romey, L. M., 2100 Paxton St., Harrisburg, Pa.
Roossin, N., 43 Schofield Dr., Newtonville 60, Mass.
Roussel, G. A., Offshore Raydist, Inc., Box 13055, New Orleans 25, La.
Rustin, G. K., 100 Howe St., New Haven, Conn.
Schlaikjer, J. E., 67 Broad St., New York 4, N. Y.
Shepp, R. E., Bldg. 7, Rm. 316, Electronics Park, Syracuse 1, N. Y.
Sokolov, D. A., CBS-Hytron, 76 Lafayette St., Salem, Mass.
Stone, D., 29, Burgh Heath Rd., Epsom, Surrey, England
Tkachuk, J. J., 316 Alvord St., Ridgecrest, Calif.
Trott, M., 1944 Clinton Ave., N., Rochester 21, N. Y.
Wagner, R. E., 535 Forrest Ave., Bethlehem, Pa.
Waters, W. P., Hughes Aircraft Co., 5315 W. 102 St., Los Angeles 45, Calif.
Weinberger, H. L., 4509 Fairview Ave., Baltimore 16, Md.
Whitney, D. B., 11 Marguerite Ave., Waltham 54, Mass.
Wilkins, W. H., 210 W. Altern St., Monrovia, Calif.
Young, L., 4305 A Alan Dr., Baltimore 29, Md.

1954
IRE DIRECTORY
DEADLINE:
Copy to set June 1st
Complete plates June 15th

TEAMED TO EXPLOIT ACCURACY

Selective Amplifier With Over 65 db Gain.
VISUAL BALANCING
High and Low Voltage Current Limited D.C.
20 db Rejection at 2nd Harmonic
Both Oscillator and D.C. Generator for Bridge Operation
Any Fixed Frequency from 100 CPS to 10 KC

esi DEKADIAL
36 feet of scale length with 38,000 discreet increments
ACCURACY — Resistance: ±0.1%; Capacitance: ±0.25%; Inductance: ±1.0%.

esi
MODEL 855-AI
OSCILLATOR AMPLIFIER

- Specifically designed to afford full utilization of outstanding accuracy and range of E S I Model 250-C1 Impedance bridge.
- Complete operation of the 250-C1 Bridge from A.C. power.
- Highly stable oscillator, accurate to within 1% of nominal frequency.
- Maximum convenience. Visual null indication. No batteries.

esi
MODEL 250-CI
IMPEDANCE BRIDGE

- Features E S I Dekadial for accurate resistance, capacitance, inductance. Readings to four significant figures.
- The most accurate, widest range Impedance Bridge available.
- Compact, light, portable. 9″ x 11″ x 11″ over all.
- Wide range:
  Resistance — 1 milliohm to 11 megohms.
  Capacitance — 1 $\mu\mu$f to 1100 μfs.
  Impedance — 1 μh to 1100 henrys.

◆ Model 855-A1 Oscillator-Amplifier $170
◆ Model 250-C1 Impedance Bridge $340
◆◆ Team $510

Write for Literature and Name of Local Sales Representative

ELECTRO - MEASUREMENTS, INC.
Formerly Brown Electro - Measurement Corp.
4312 S. E. STARK STREET - PORTLAND 15, OREGON

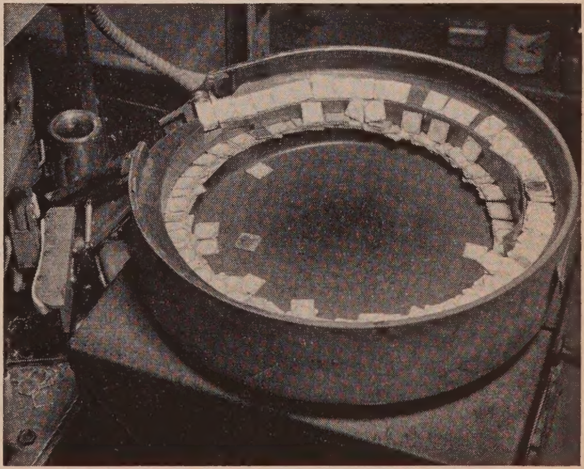
esi

ZOPHAR
---WAXES
---COMPOUNDS

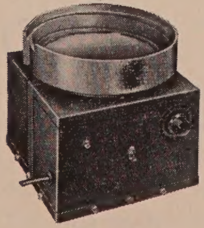
Zophar Waxes, resins and compounds to impregnate, dip, seal, embed, or pot electronic and electrical equipment or components of all types; radio, television, etc. Cold flows from 100°F. to 285°F. Special waxes non-cracking at —76°F. Compounds meeting Government specifications plain or fungus resistant. Let us help you with your engineering problems.

108 YEARS
ZOPHAR MILLS, INC.
112-130 26th Street,
Brooklyn 32, N. Y.

"Short Cut" To Economical Production with
SYNTRON PARTS FEEDERS



Feeding titanate capacitors for soldering operations in automatic assembly of electronic equipment.



Positive, finger-tip control of feeding rates plus ability to handle small parts of nearly any material or shape enable Syntron Parts Feeders to cut production costs and increase capacities of countless automatic processing installations. Electromagnetic—no mechanical wearing parts—easy to install.

Write today for complete catalogue data—Free

Don't miss SYNTRON'S Booth No. 1960

SEE OUR EXHIBIT
1954 INDUSTRIAL EXPOSITION
PHILADELPHIA CONVENTION CENTER
APRIL 26-30 incl.
AMERICAN SOCIETY OF TOOL ENGINEERS ASTE

SYNTRON COMPANY
242 Lexington Ave. Homer City, Pa.

ALLIED world's largest distributor of

ELECTRON TUBES FOR INDUSTRY

ALL BRANDS IN STOCK
AMPEREX
G.E.
EIMAC
RCA
RAYTHEON
SYLVANIA
TAYLOR
TUNGSOL
VICTOREEN
WESTINGHOUSE
and others

ALL TYPES IN STOCK
Power Tubes
Rectifiers
Phototubes
Radiation
Sub-Miniature
Oscillograph
Transistors
Ignitrons
Thyratrons
Image Orthicon
Klystron
All Special Purpose Tubes

IMMEDIATE DELIVERY FROM STOCK

ALLIED stocks for *quick shipment* the world's largest distributor inventory of special-purpose electron tubes. We specialize in supplying the needs of industrial, broadcast, governmental and other users. To save time, effort and money—phone, wire or write to ALLIED for fast expert shipment.

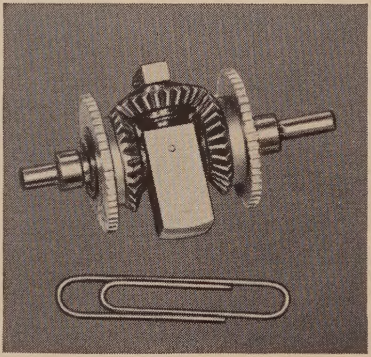
Refer to your ALLIED Catalog for *all* electronic supplies. Write today for a FREE copy of the complete 268-page 1954 ALLIED Catalog.

Everything in Electronics from One Dependable Source

ALLIED RADIO
100 N. Western Ave.
Dept. 35-D-4, Chicago 80, Ill.

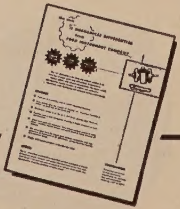
the NEW

1/8" MECHANICAL DIFFERENTIAL
from
FORD INSTRUMENT COMPANY



- Operates in working circle of 1.000" max. diameter
- Lost motion does not exceed 12 mins.
- High sensitivity
- Stainless steel throughout; resistance to wear and corrosion
- Uses Zerol bevel gears.
- Weight, with typical end gears, is less than one ounce

The 1/8" differential is the latest and smallest addition to the Ford Instrument line of single spider gear differentials. Engineered to highest military and commercial standards, this highly reliable unit provides extreme accuracy in additive and subtractive operations, while functioning with minimum friction and backlash.



WRITE FOR FULL DETAILS

Fully illustrated data sheet gives performance curves and characteristics. Please address Dept. IRE.

21

FORD INSTRUMENT COMPANY
31-10 THOMSON AVENUE
LONG ISLAND CITY, N. Y.

Student Branch Meetings

(Continued from page 130A)

"Factors in Design of Vacuum Tubes" by Mr. C. Garretson, Raytheon Mfg. Co.; October 19, 1953.

Movies, "Magic in the Air" and "Principles of F.M."; October 24, 1953.

"A Look at the Outlook" by Mr. Hollander, Faculty, New York Univ.; November 9, 1953.

"Computer Fundamentals" by Mr. J. Smith, Faculty, New York Univ.; November 16, 1953.

Business Meeting; November 23, 1953.

Tour of Oyster Bay with demonstration of electronic equipment by Ships Company; November 28, 1953.

"Color Television" by Mr. A. J. Farber, Hazeltine Corp.; December 4, 1953.

"Practical Applications of Electronics in Atomics" by Mr. T. V. Sheehan, Brookhaven Laboratories; December 7, 1953.

"Applications of Computers in Business & Industry" by Mr. S. S. Klossman, I.B.M.; December 14, 1953.

"Principles of Klystron Operations" by Mr. Zemanian, Faculty, Univ. of New York; December 21, 1953.

"Recent Applications of Klystron Tubes" by Mr. Charles E. Rich, Sperry Gyroscope Co.; January 4, 1954.

NORTHEASTERN UNIVERSITY IRE-AIEE BRANCH

Field Trip to New England Telephone and Telegraph; December 17, 1953.

UNIVERSITY OF NOTRE DAME IRE-AIEE BRANCH

"Elements of Radar" by Mr. Eric J. Isbister, Sperry Gyroscope Co. and General Meeting; October 7, 1953.

"Role of the Electrical Engineer in the Aircraft Industry" by Mr. Robert H. Glass, Boeing Aircraft Corp. and General Meeting; October 29, 1953.

"Engineering in the Future" by Mr. Chestnut, General Electric Co. and General Meeting; November 5, 1953.

"Electrical Engineering in India" by Mr. G. Abrahams, recent graduate student at Notre Dame from India; and General Meeting; December 2, 1953.

"Computers" by Mr. Marvin A. Govro, Faculty Notre Dame and General Meeting; January 14, 1954.

OHIO STATE UNIVERSITY IRE-AIEE BRANCH

"Illumination Engineering" by Mr. Franck of the Holophane Co. of Ohio; November 19, 1953.

"Field Trip through Ohio Bell Telephone Exchange"; January 14, 1954.

(Continued on page 148A)

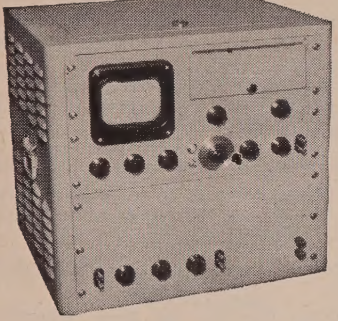
1954
IRE DIRECTORY

DEADLINE

Copy to Set June 1st

Complete plates June 15th

SPEED UP



AUDIO WAVE FORM ANALYSIS

PANORAMIC SONIC ANALYZER LP-1

Many engineers find that Panoramic's LP-1 expedites their entire measurements program. LP-1 analyzes sound vibrations and electrical waveforms quickly, conveniently, accurately. Designed to eliminate the tedious problems commonly associated with audio wave form analysis, the Panoramic technique provides valuable visual information *in seconds!*

- **Visualizes frequency and amplitude of waveform components between 40 and 20,000 cps; magnifies small portions of spectrum for detailed analysis; displays easily photographed; scans spectrum in 1-second; analyzes changing and static phenomena.**

It will pay you to investigate the many unique advantages of LP-1.

SPECIAL APPLICATIONS

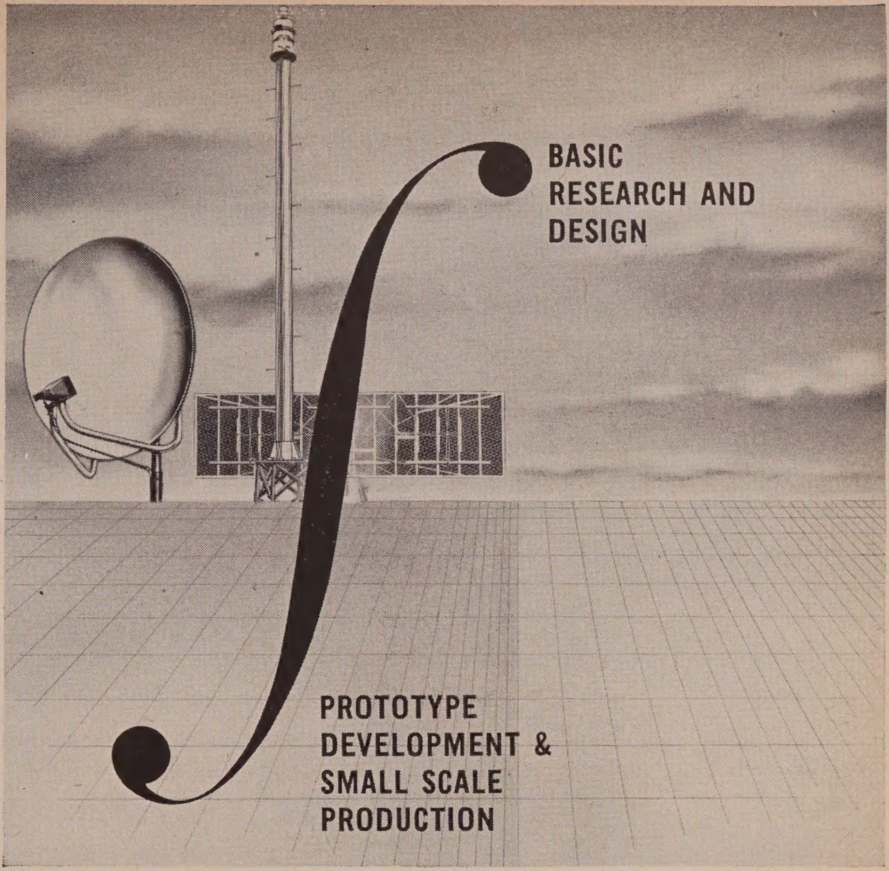
- Investigations of closely spaced sound and vibration frequencies
- Harmonic analysis of waveforms having low frequency fundamentals
- Spectrum analysis requiring constant band width.

Panoramic's LP-I offers scores of unique advantages; it will pay you to check their application to your problems.

PANORAMIC
RADIO PRODUCTS, INC.

Write Today For Complete Specifications.

10 South Second Ave., Mount Vernon, N.Y.
Phone: MOunt Vernon 4-3970


BASIC RESEARCH AND DESIGN
PROTOTYPE DEVELOPMENT & SMALL SCALE PRODUCTION

Integrated ANTENNA RESEARCH AND DEVELOPMENT

Antennas must be designed to fit the needs of each particular situation . . . a job for specialists. The Gabriel Laboratories are antenna specialists, experienced in handling all types of antenna and microwave problems — from basic research and design through prototype development and small scale production. We can also assume full responsibility for large scale production because of the extensive, specialized manufacturing facilities of our affiliate, Gabriel Electronics Division.

On our staff are several of the top ranking antenna specialists in the country. The research and test facilities include several microwave pattern ranges, altitude and temperature chambers, and the usual measurement and test equipment necessary to determine antenna performance and characteristics over the entire radio and microwave spectrum.

The government and many of the country's largest electronic companies have solved their toughest antenna problems by coming to The Gabriel Laboratories.

For analysis of your antenna or microwave problem, write or phone NEedham 3-0005.

THE GABRIEL LABORATORIES
THE GABRIEL COMPANY
135 CRESCENT STREET, NEEDHAM HEIGHTS, MASS.

SIGMUND COHN MOUNT VERNON, N.Y.

ELECTROPLATED *Wires*

Corrosion Resistance

Better Solderability

Suppression of Grid Emission

Improvement of Electrical Characteristics

SINCE 1901

GOLD, SILVER, RHODIUM, PLATINUM
and other metals, applied to many different types of wire to meet your specifications. Uniform plating, scientifically controlled.
Write for Latest List of Products

SIGMUND COHN MFG. CO. INC. 121 So. Columbus Avenue, Mt. Vernon, N. Y.

COLOR TV Wickes EQUIPMENT

COLOR CONVERSION PACKAGE

An integrated basic package for producing color signals. Converts monochrome synchronizing generator for color, generates standard color bars, and encodes output of Color Bar Generator, color camera chain, or color slide scanner to produce composite color video signal. Requires 70 inches of standard rack space.

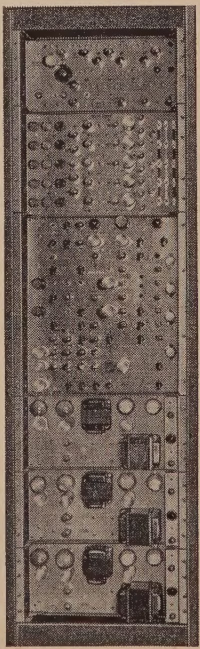
Interlace Signal Generator ISG-2.
Generates subcarrier of 3.579545 mc ± .0003%.
Supplies one subcarrier output at 75 ohms for Color Coder.
Isolation amplifiers provide three additional 75-ohm subcarrier output circuits.
Supplies 31.5 kc signal for locking synchronizing generator.
Provides 1575 kc test marker pulse.

Color Bar Generator CBG-1.
Five adjustable pedestal forming channels.
Allows choice of several bar patterns. Two frequently used combinations are:
1. Six colors plus black and white.
2. White, black, two primary colors, and two mixture colors, plus *I* and *Q* or *R-Y* and *B-Y*.

Color Coder CC-1.
Matrixes red, green, and blue signals to produce luminance signal, *I*, and *Q*.
Produces *R-Y* and *B-Y* which quadrature-modulate subcarrier signal in doubly-balanced modulators.
Adds together composite synchronizing signal, chrominance subcarrier signal, and luminance signal to produce composite video signal.
I, *Q*, *R-Y*, and *B-Y* can be turned off individually.
Composite video signal can be used to modulate television transmitter, or distributed to color video monitors and test positions.

Power Supplies.
Provide regulated B+ voltage and filament voltage for all units in the conversion package.

Above units can be supplied as individual items. Other color test instruments are available. Additional specifications and prices forwarded upon request.



Wickes ENGINEERING AND CONSTRUCTION COMPANY
12th STREET AND FERRY AVENUE
ESTABLISHED 1920
CAMDEN 4, NEW JERSEY

Student Branch Meetings

(Continued from page 146A)

OKLAHOMA AGRICULTURAL & MECHANICAL COLLEGE IRE-AIEE BRANCH

"The Future for Electrical Engineers" by Mr. J. Elden Peek, Graduate, 1930 O.A.M.C.; January 11, 1954.

UNIVERSITY OF SOUTHERN CALIFORNIA, IRE-AIEE BRANCH

"Electrical Power Generation by Atomic Energy" by W. Scott, General Electric Co." December 16, 1953.

Election of Officers; January 11, 1954.

"Computers" by Donald D. Wall, I.B.M.; January 12, 1954.

UNIVERSITY OF SYRACUSE IRE-AIEE BRANCH

"Pumped Storage on the Niagara River" by Mr. Earl Strowger, Niagara Mohawk Power Corp.; January 6, 1954.

TEXAS TECHNOLOGICAL COLLEGE IRE-AIEE BRANCH

Film, "Freedom and Power"—Southwestern Public Service Co.; September 28, 1953.

Film, "Along the Right of Way" and General Meeting; October 14, 1953.

"The Growth of Power in West Texas" by H. L. Allen, V.P. Southwestern Public Service Co.; November 16, 1953.

Tour of KCBD-TV; December 7, 1953.

General Meeting; January 11, 1954.

TULANE UNIVERSITY IRE-AIEE BRANCH

"Fundamental Theory of Transistor Operation" by D. W. Boensel, IRE Junior and "Single-Side Band Transmission" by W. T. Herrmann, AIEE Senior; December 15, 1953.

VIRGINIA POLYTECHNIC INSTITUTE IRE-AIEE BRANCH

Business Meeting; January 12, 1954.

"The Future of Electrical Engineers with the Appalachian Electric Power Co." by J. D. Lawrence, Appalachian Electric Power Co.; January 19, 1954.

UNIVERSITY OF WASHINGTON IRE-AIEE BRANCH

Business Meeting; October 12, 1953.

Meeting for Awards presented by Professor Eastman and Dean Wessman; October 20, 1953.

Field Trip to Baker River and City of Seattle hydro-electric project on the Skagit River; October 24th and 25th, 1953.

"Transistor Development at Bell Labs" by Mr. Fred J. Singer, Bell Laboratories; November 4, 1953.

Business Meeting and Film, "High Lines"; November 17, 1953.

WAYNE UNIVERSITY IRE-AIEE BRANCH

"The Detroit Edison Communication System" by Mr. A. B. Buchanan, Detroit Edison and Election of Officers; December 17, 1953.

UNIVERSITY OF WISCONSIN IRE-AIEE BRANCH

"Recent Developments in the Power Field" by Mr. Chestnut, General Electric Co.; November 12, 1953.

"Nuclear Power" by Prof. Sacks, Faculty of Univ. of Wisconsin; December 16, 1953.

UNIVERSITY OF WYOMING IRE-AIEE BRANCH

Business Meeting; January 12, 1954.

YALE UNIVERSITY IRE-AIEE BRANCH

"Industrial Training and Opportunities" and "Modern Motor Control Methods" by Messrs. Arloe W. Paul and Charles F. Walker, both from Allen-Bradley Company; December 16, 1953.

"The Application of Traveling-wave Tubes to Microwave Communications" by Mr. A. K. Wing, Federal Telecommunication Labs., Nutley, New Jersey; January 12, 1954.